

Radio Control Annual 5



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RADIO CONTROL ANNUAL

5

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INTRODUCTION

RADIO CONTROL ANNUAL 5 continues the pattern set by our *Radio Control Manual* series which commenced back in 1965. Since then, the "Manuals" have chronicled the ever advancing state of the art in the radio controlled model hobby, following the emergence of new specialist interests—pylon racing, gliders, the achievement of R/C helicopters etc. R/C Manual also followed the vast improvements in radio control equipment during the past eight years, following the progress from the bulky, cumbersome non-proportional systems, through the first proportional equipments—the battle between analogue and digital concepts, to today's ultra light, highly reliable systems.

Radio Control equipment today owes everything to the rapidly advancing state-of-the-art in more commercial fields of electronics. During the past year, major difficulties have arisen due to shortages of electronic components. Three years ago when the U.S. space and military programmes began to slow, manufacturers of integrated circuits actively sought new outlets. The R/C equipment industry benefited, with some significant breakthroughs as a result, but more recently, business in integrated circuit manufacture has picked up due to the demand for pocket calculators, computers and electronic safety circuitry from the U.S.A. automotive industry, the latter prompted by new safety laws.

All this has left our radio control equipment industry in something of a short supply situation as regards components, but happily an improvement in the situation is now in hand.

Radio control equipment manufacturers really are to be congratulated on the extensive improvements achieved over the past two years, rarely at any direct cost increase to the customers. However, our 27 MHz waveband becomes continually more crowded. Although R/C systems in Britain operate on a "sport frequency" band spacing of 50 KHz, many stations used for industrial purposes operate at frequencies interspaced between our "spots". Consequently, we see that even more ingenuity may be called for as the need for greater selectivity in equipment operation becomes an ever more pressing necessity.

RADIO CONTROL ENGINE DEVELOPMENTS

By Peter Chinn

THE subject of radio-control engine development was previously dealt with in Radio Control Manual No. 2 some six years ago. Since that time, very considerable advances have taken place. In fact, more progress has been made in commercial model engine design during the past five years than over any similar period in the last two decades. Not only does the R/C enthusiast now enjoy higher performance, better handling, improved throttle systems and a much wider range of types from which to choose: he may also, if he so wishes, move away from the single cylinder two-stroke to more exotic designs, such as the O.S. Wankel rotary-combustion engine from Japan, or the Ross twin and multi-cylinder motors from America.

The expansion and diversification of the R/C engine market is, of course, all part of the rapid increase in the popu-

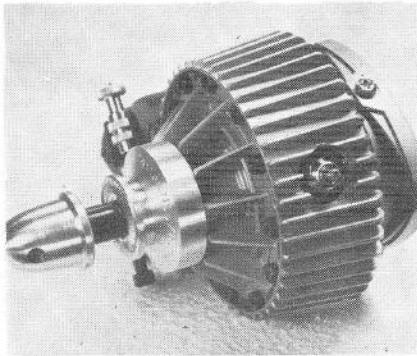
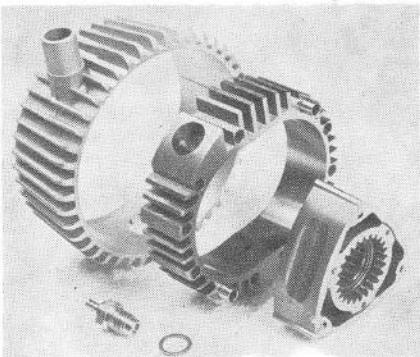
larity of radio-control that has occurred in recent years in all the more advanced countries of the world.

Broadly, one can now divide R/C engines into four groups—at least so far as aircraft are concerned. These, we suggest, might be classified as follows:

1. *Trainer and General Purpose.* Mostly comprising the less expensive engines ranging from .09 cu. in. (1.5 c.c.) to .36 cu. in. (6 c.c.) suitable for trainers, intermediate and other models requiring rather less than the highest levels of engine performance.

2. *40's and 60's.* These mainly comprise the powerful .60—.61 cu. in. (10 c.c.) engines favoured for aerobatic contest models and for large single-engined scale models, plus certain high performance .40 cu. in. (6.5 c.c.) engines which, for various reasons, are becoming popular for 'club' flying.

The O.S. 5 c.c. Wankel rotary combustion engine. Powerful, very smooth and a truly remarkable feat of design and production engineering.



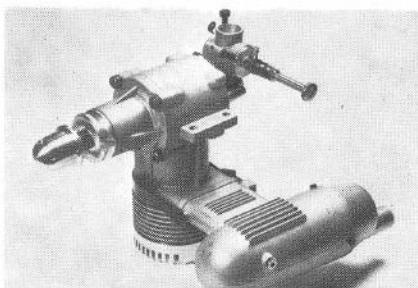
3. *Racing 40's.* A small specialised group of motors (only four or five makes at present) intended solely for pylon racing. Can be expensive.

4. *Specials.* Rotary, twin and multi-cylinder types, plus engines outside the FAI 10 c.c. capacity limit. Expensive.

It is not the purpose of this article to report in detail on every R/C engine that has been added to the market since our earlier review. Illustrated descriptions and test reports have, in any case, been published on most of these in *Radio Control Models & Electronics*. Instead, we will attempt to update our previous (1967) progress report by dealing with the more significant developments that have taken place.

The year 1967 closed with the promise of some very interesting developments for the future. During the summer of that year, the Japanese O.S. company had, at the request of the West German Johannes Graupner concern, undertaken to develop and manufacture a production version of the 5 c.c. Wankel engine that had been designed for Graupner by Ing. Schaeegg and which, basically similar to the Wankel engines now proving so successful in the German NSU Ro.80 and Japanese Mazda cars, had taken several years to bring to fruition. The involvement of O.S. in the matter was, however, kept secret until October 1968 when O.S. pre-production models, including an experimental twin-rotor 10 c.c. version were publicly demonstrated.

Actual manufacture of the O.S. Graupner 5 c.c. Wankel motor began in the following year, first with a pilot run of fifty engines, followed by an initial production batch of two hundred. The writer received one of the pre-production models for evaluation and this, after testing, was used in a model to make the first flights by a rotary-engined aircraft in the U.K. As more experience with this entirely

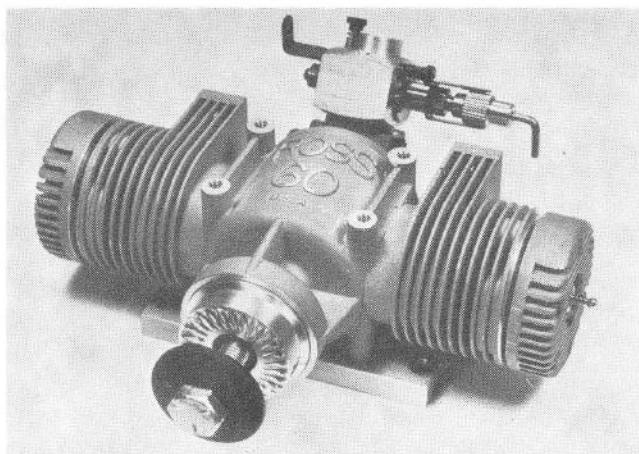


O.S. Max-H.80, largest single cylinder engine in production, has many useful extras. Ideal for big scale jobs or marine use.

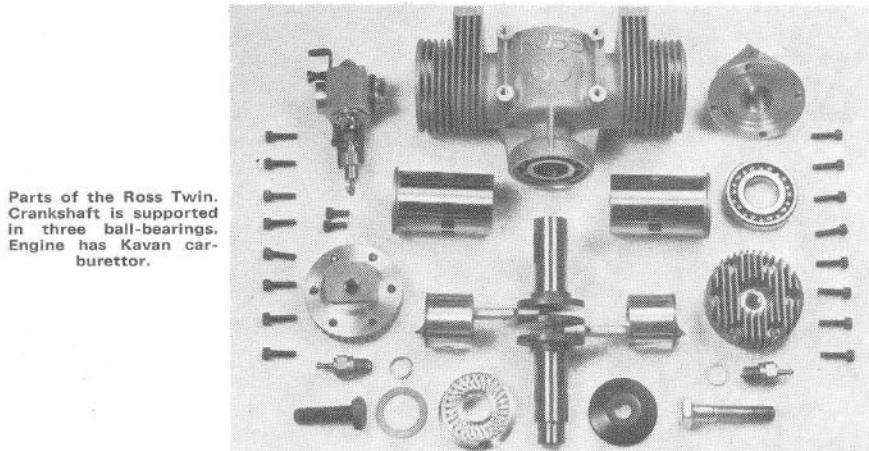
new type of model engine was accumulated, O.S. steadily improved it by minor modifications here and there and, far from being a mere curiosity or a collector's item, the O.S. Graupner 5 c.c. Wankel motor has shown itself equal, if not superior, to reciprocating engines of equivalent displacement. It is powerful (around 0.70 b.h.p. at 16,000 r.p.m. on standard fuel), easy to start, has excellent throttle response and, as one would expect of a rotary motor, is outstandingly smooth running. Requiring only a small silencer to cope with its continuous exhaust gas discharge, it is also remarkably quiet. In this engine's manufacture, much closer tolerances are required than for reciprocating engines and O.S. have made an outstandingly fine job of producing it. The motor is currently priced in the U.K. at around the £60 mark.

The American Ross engines are another example of recent model engine design and manufacture where quality, rather than cost, has been the first consideration. First made in small numbers by their designer, Louis Ross, these engines were later built at the Northfield Precision Instrument Corporation's factory on Long Island, but Ross has now formed a new company, Rosspower Inc., for their manufacture.

Production began with the 10 c.c. Ross 60 horizontally-opposed, simul-



The excellent Ross 60 flat-twin engine. It weighs no more than a single cylinder 60.

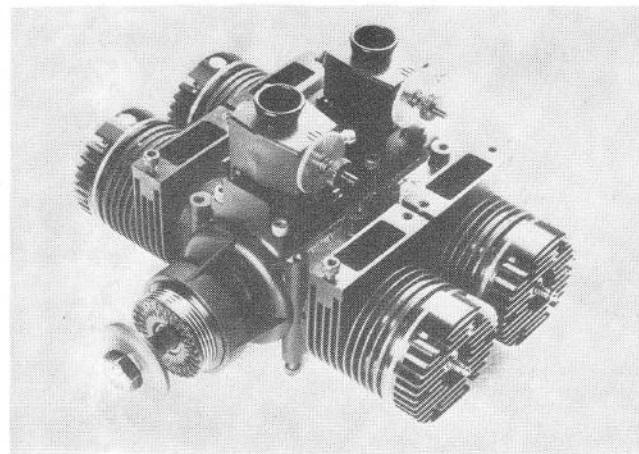


Parts of the Ross Twin. Crankshaft is supported in three ball-bearings. Engine has Kavan carburettor.

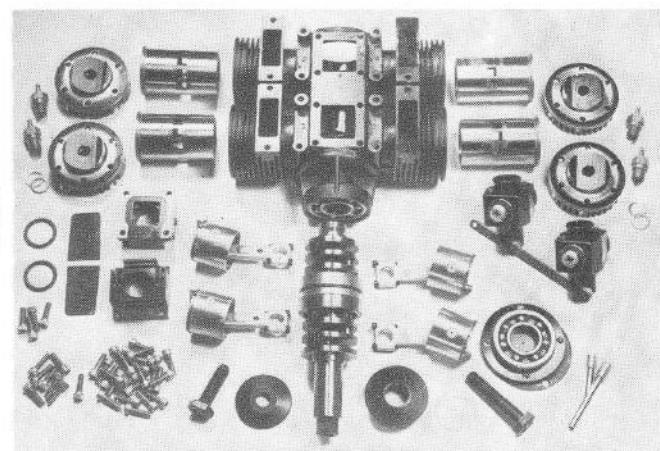
taneous-firing, twin-cylinder motor and now includes flat-four and flat-six cylinder models of 20 c.c. and 30 c.c. respectively. Remarkably compact, these engines feature directly opposed cylinders, the connecting-rods being staggered, rather than the cylinders themselves. Overall lengths of the multi-cylinder models are further reduced by using reed-valve induction to the individual crank chambers, each being fitted with its own carburettor—i.e. two carburettors for the Four and three for the Six. Perry carburettors are used, with coupled throttle linkages.

We have had both the Twin and the Four on test and can confirm that they perform as well as they look. The Twin, priced at \$125 in the U.S. and somewhat higher in the U.K. is, all things considered, not expensive by comparison with more conventional good quality engines. The quite splendid Four and Six, naturally, are a good deal more costly at \$465 and \$665 respectively.

The main advantage of an engine such as the 20 c.c. Ross flat-four, apart from its uncannily vibration-free running qualities and, of course, the



The magnificent Ross horizontally opposed 20 c.c. four-cylinder motor from the U.S.A. Very compact and only 26 oz. weight.

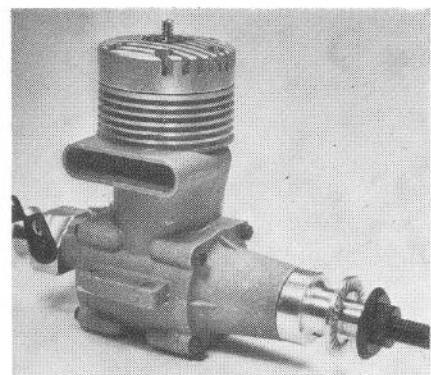


The parts of the Ross Four. A truly superb engine which is powerful and unbelievably smooth running.

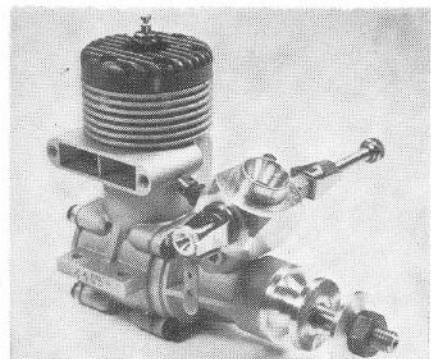
sheer delight of owning such an impressive piece of machinery, is its ability to swing a really big prop—anything between 14 and 18 inch diameter in fact—which is just what one needs for lifting a heavy, bulky scale model. Unfortunately, engines of over 10 c.c. are outside the FAI limit for contest purposes but where such models can be safely flown (with valid insurance cover), a few c.c.'s over the limit can make all the difference.

This has been convincingly demonstrated on many occasions by the 13.24 c.c. O.S. Max 80. Tested

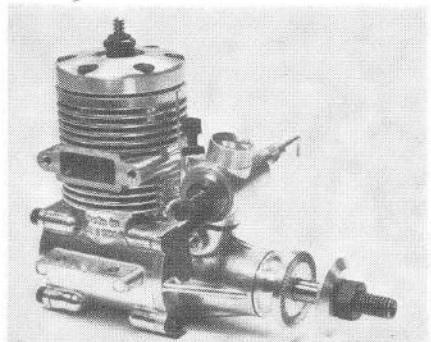
recently in its latest improved version (enlarged valve rotor, modified shaft and single ring piston) the O.S. 80 out-tuned most of the 60's by upwards of 600 r.p.m. on a 14×6 prop and went on to handle 15, 16 and 17 inch props with ease. Starting, running and throttling characteristics were excellent. The 80 is only 2 to 3 ounces heavier than the average 60 and is quite compact. It is also a most versatile engine: its valve rotor has an alternative drive slot enabling the engine to be instantly converted to opposite rotation; the complete carb



Above: 1971 K&B Torpedo 40 Series 71R, the final development of the very successful Torpedo 40 series originated in 1966.

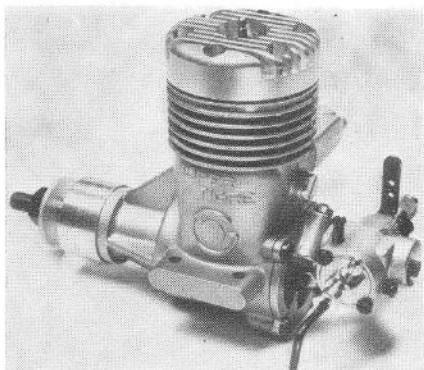
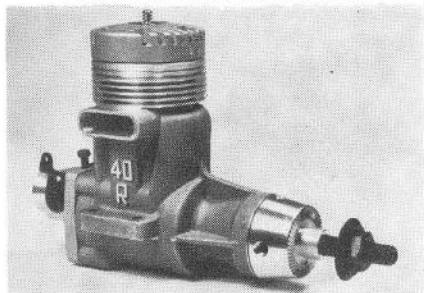


Above: Webra 40 R/C. Basically this is a scaled down Blackhead 61 and has performance to match.

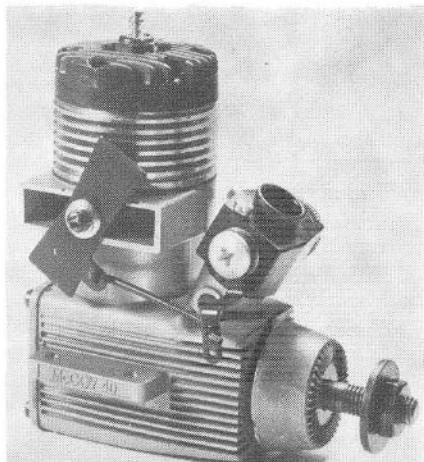


Above: The HP 40F-RC, one of the most powerful aerobatic type .40 cu. in. engines offered to date.

Below: 1972 pre-production model K & B 40R. Only 100 made. These engines dominated U.S. pylon racing circuits during 1972-73.



Above: Super-Tigre G.40-ABC. Another pylon-racing contender, but likely to be superseded for PR by new STX-40 model.

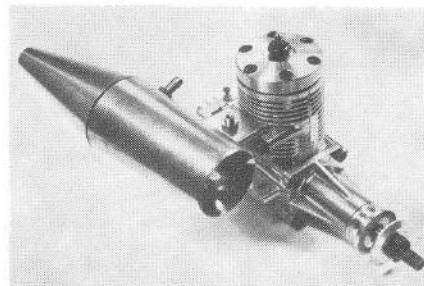


Above: American McCoy 40 R/C is also made in .29 and .35 versions. Bushed main bearing. Not yet available in U.K.

assembly can be rotated through 180 degrees for relocating the intake upright for inverted installations and the engine is quickly adapted to marine use by means of an optional watercooled head.

When our 1967 report was published, pylon racing engines, as a specific type, did not exist. They began to emerge with the throttle equipped version of the American K&B Torpedo 40 Series 67 rear disc valve control-line 'rat racing' motor and, over the ensuing four years, this design, through Series 69, 70 and 71 versions each developing more power, became firmly entrenched as 'the' pylon-racing unit. By 1971, however, it was apparent that the highly successful Torpedo crossflow scavenged design had just about reached the limit of its development and a new design with Schnuerle scavenging and a more rigid one-piece body casting, was laid down.

A pilot-run batch of one hundred of these engines was produced in 1972, forthwith set new standards of performance in the Formula I pylon racing class with times of well under 1 min. 30 sec. (and later under 1:25) for the regular pylon racing course, and also caused considerable agitation among those enthusiasts who had not been among the favoured few to be allocated one of the hundred. Our test unit produced a highly impressive 1.6 b.h.p. at 20,000 r.p.m. on 50 per cent pure nitromethane fuel but it is anticipated that future production models will better this by at least 10 per cent. At the moment, the engine is set up for Formula I class racing only, but a special FAI version for operation on straight methanol/castor-oil fuel is planned. The engine retains the .840 x .720 in. bore and stroke combination and Dykes piston ring of previous K&B 40's and, despite a hefty appearance, is only about 1 oz. heavier.

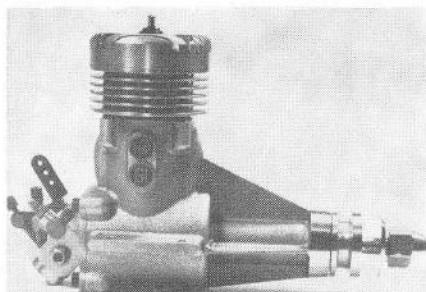


Rear disc valve HP 40R with HP air-scavenged silencer. PR version has been successful in FAI pylon racing.

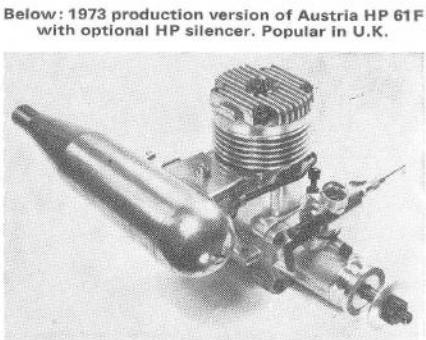
The only engines to have challenged K&B supremacy in pylon racing have been the Italian Super-Tigre G.40-ABC and the Austrian Hirtenberger HP 40R-PR. Super-Tigre successes have mostly been in the U.S. and generally as a result of the attentions of tuning specialists. The Austrian engine, on the other hand, has done particularly well in the U.K. in FAI racing where the stock HP 40R-PR has proved more than a match for the old Torpedo 40. (At the time of writing, the Schnuerle scavenged K&B 40R has yet to appear in competition outside the U.S.).

The HP was actually designed as far back as 1967 and was first seen in prototype form early in 1968, but underwent a protracted period of development including outside evaluation via a pre-production batch in 1970 before getting into regular production in 1971. Had the HP reached its 1972 level a couple of years earlier, it would undoubtedly have made a very considerable impact, anticipating, as it did, the new K&B and other pretenders to the pylon racing crown, by featuring Schnuerle type porting from the beginning.

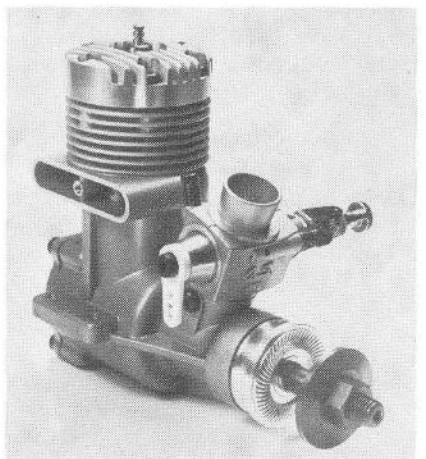
This scavenging system was, in fact, pioneered by Hirtenberger so far as commercial model engines are concerned and its value from the performance standpoint, already recognised



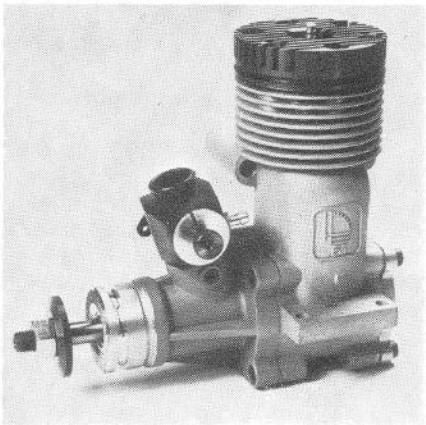
Above: pre-production HP 61 of 1967 set new standards of performance but its length and awkward carb were unpopular.



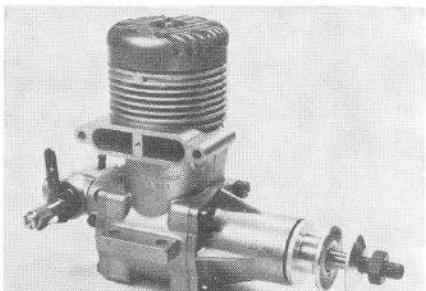
Below: 1973 production version of Austria HP 61F with optional HP silencer. Popular in U.K.



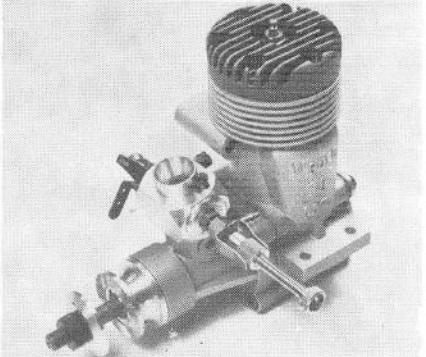
Above: good example of modern high-powered aerobatic '40', is 6.5 c.c. O.S. Max 40 R/C. Many '60' engine features.



Below: West German Webra 61, not too well known in U.K., but very successful in U.S.A.



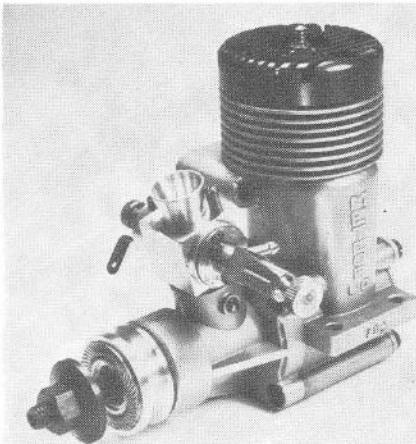
Above: Latest version of Italian Super-Tigre G.60RV R/C engine. Heavy but solidly constructed and finely finished.



in the full-scale racing two-stroke engine field, was convincingly demonstrated by the prototype Paul Bugl designed rear-induction HP 61 in 1967 which, on test, outperformed all 10 c.c. R/C engines produced to that time. Unfortunately, certain other features of the engine, notably its considerable length and its awkwardly placed and difficult to adjust carburettor, did not go down too well with practical R/C modellers and it was not until 1970, when the Austrian factory introduced the HP 61F, a shaft-valve version of the 61 fitted with a simple automatic mixture control carburettor, that the HP really became established as a competitor in the 10 c.c. R/C aerobatic engine field.

The HP 61F (helped initially by a low selling price) has become quite popular in the U.K., perhaps to the detriment of Britain's own Merco 61, but the Merco continues to sell in overseas markets and now in production is an improved version of the Merco which looks good and should offer a strong challenge to the imports. It has a new carburettor, larger ports, a higher compression ratio and a rebalanced crankshaft.

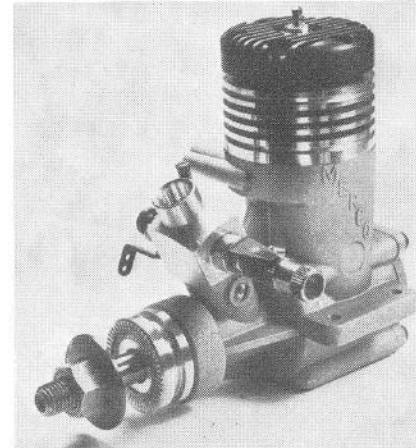
The range of '60' and '61' class engines on the market is larger than ever and substantial improvements in power output, throttling and durability have been made since our earlier report. In 1967, the favoured R/C engines were producing slightly less than 1.0 b.h.p., unsilenced, on standard test fuel (5 per cent nitromethane) but, within two years, this figure had been exceeded with silencers, while gross outputs had gone up by 25 to 30 per cent with such engines as the Webra 61 Blackhead, the O.S. 60 and 60F Gold-Head and the HP 61F. The Webra, designed by the late Gunther Bodemann and made in West Berlin, has enjoyed considerable contest success, particularly in the United States.



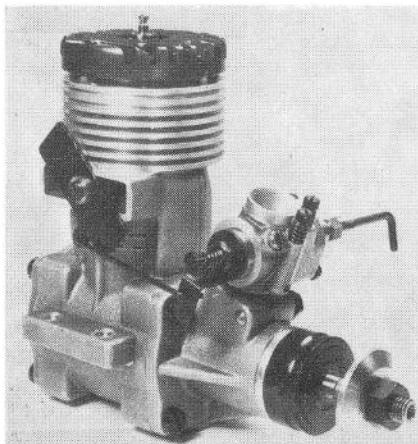
Regular production of this new British make, the Meteor 60, began in 1972. Has the usual 60 R/C features.

It has now been joined by a new Schnuerle scavenged model developed by former HP designer Peter Billes and manufactured at a new Webra factory in Austria. The O.S. is available in two versions: one with orthodox shaft rotary-valve induction and the other with a drum rotary-valve at the rear like the O.S.80.

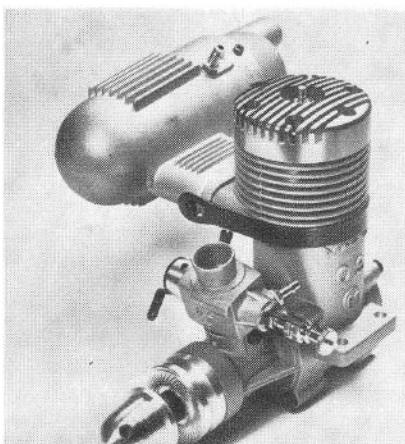
Some completely new makes in the 10 c.c. class have appeared since our



Improved 1973 model Merco 61. British Merco pioneered larger, ringed-piston, twin ball-bearing R/C engines in 1961.



OPS Ursus 60 engine from Italy has Schnuerle scavenging and ringless aluminium piston running in chromed liner.



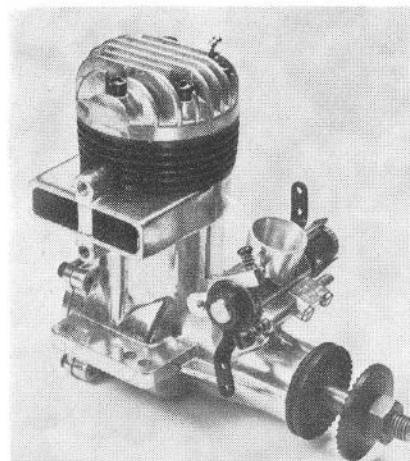
O.S. Max-H.60F 'Gold-Head' with latest O.S. automix carb. Silencers are included with all O.S. motors.

previous report. Significant among these are the German HB-61, the Italian OPS 60 and the Japanese YS-60. The initials HB stand for Helmut Bernhardt, a radio-control modeller from the earliest days of multi-channel R/C in Germany, who has now put part of his sizeable automobile instrument-making company to the task of producing model engines. These engines were first marketed under the name 'Veco Europe Series' by arrangement with the American K&B company (manufacturers of the 'real' Veco motors) presumably as an aid to getting them established, distribution being through the old-established Schuco firm. In fact, the 'Veco Europe Series 61' bears little resemblance to the American Veco 61 (it is much closer to the Webra 61) and the same engine is now also marketed through Johannes Graupner as the HB-61. Performance of our test sample was good and especially notable was the motor's above-average pulling power on the larger prop sizes. It is now available in a special version for helicopters.

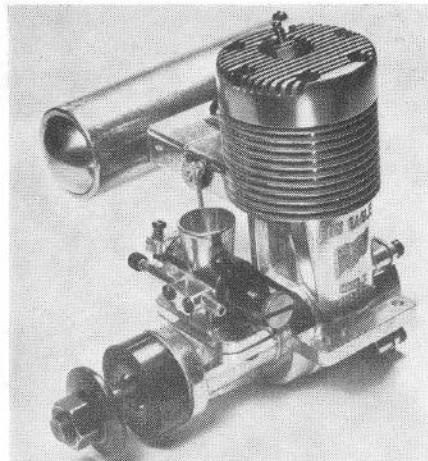
The manufacture of OPS engines

began with the small scale production of a Schnuerle scavenged racing engine with Zimmermann type disc-valve induction and tuned-pipe rear exhaust for control-line speed models and racing hydroplanes. The emphasis continues to be on engines of this type, although the company now also makes a robust shaft-valve, side-exhaust motor, the 'Ursus 60' for regular R/C use. OPS are also making a range of high performance .40 cu. in. engines including a pylon racing unit. OPS 60 racing engines have achieved some notable successes in European contests and it will be interesting to see how their .40 shapes in pylon racing.

The YS 60, made by the Yamada Manufacturing Company Ltd., is, in many ways, one of the most interesting developments of recent years. Basically the engine is orthodox insofar as it is a shaft rotary-valve, twin ball bearing, crossflow-scavenged, ringed-piston engine of 24×22 mm. bore and stroke but, unlike any other production model motor at the present time, it uses a chromed aluminium cylinder-liner and incorporates a completely new concept in fuel systems.



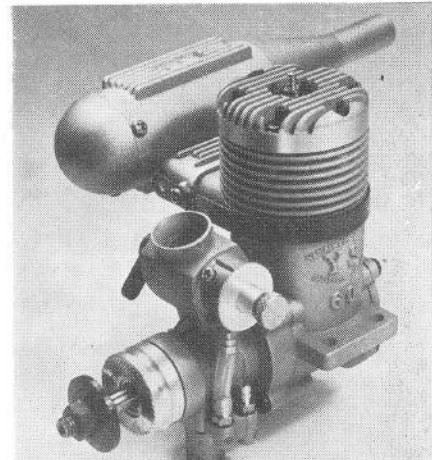
Fox Falcon, rare among 60's in having a bronze main bearing instead of ball races, but very good value.



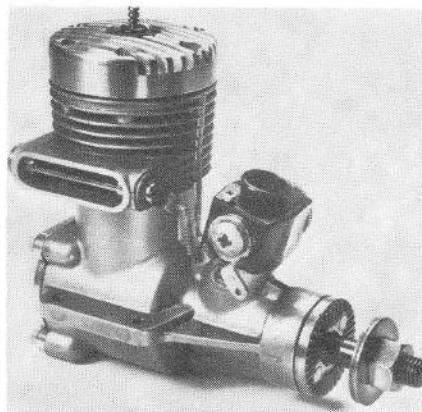
The American Fox Eagle 60 with the optional Fox silencer that is available as an extra.

of 1.35 b.h.p. at 16,000 r.p.m. using standard 5 per cent nitro fuel.

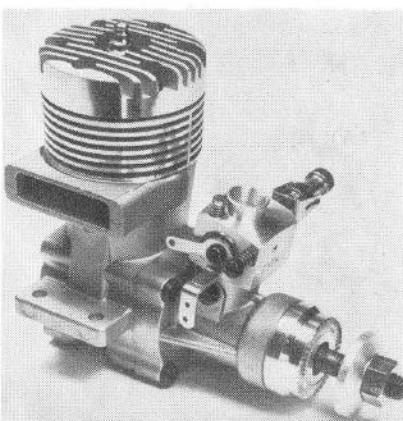
The YS system involves the use of a high pressure (rotary-valve timed) crankcase tapping and a non-return valve in the fuel tank. A much simpler and milder form of fuel tank pressurisation that has become popular during the past two or three years is to tap silencer pressure. Webra, O.S.,



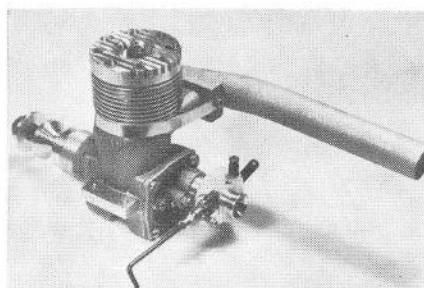
New Japanese YS-60 is unique in having built-in fuel regulator that makes it immune to variations in fuel pressure.



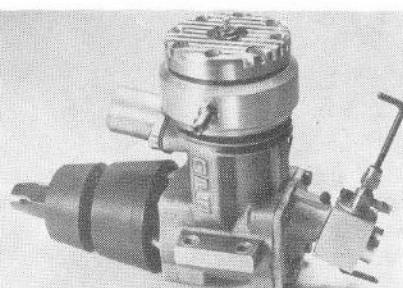
American Veco 61, made by K&B company. This is a 'customised' version assembled by designer Clarence Lee.



Latest version of the Japanese Enya 60 is this Mk. III-B with Enya G-8 large choke carburettor.



The very powerful Italian Rossi 60 R/C motor, here fitted with the special exhaust pipe available for it.



OPS Speed-60 R/C Racing Marine unit features Zimmermann type disc valve and tuned pipe rear exhaust.

HP, HB, Super-Tigre and Enya all now equip their silencers with outlet nipples for this purpose and there is no doubt that pressurising the tank in this way helps to even out minor variations in fuel delivery pressure and thereby reduce the risk of the engine cutting-out during certain manoeuvres. It is especially helpful where carburettor choke areas are slightly larger than normal and it is specifically recommended by Enya for the latest Enya 60-IIIB model when fitted with the optional Enya G-8 carburettor and by HP for use with the new Hirtenberger AFM carb.

On the subject of carburettors, the desirability of having some form of

automatic fuel metering (again, especially with large choke carbs) is now widely accepted and practically all modern R/C 60's now incorporate this. Usually some form of adjustment is provided whereby the idle mixture can be set independently of the main needle-valve and the approximately correct mixture strength is then maintained automatically at intermediate throttle settings.

In addition to higher power outputs and better throttle control, current 60's are generally easier to handle and more durable than their predecessors. Improvements in piston rings, combustion chamber shapes and shaft balancing have resulted, in many cases,

in quicker starting, more docile handling characteristics and smoother running qualities. The need for greater durability has led to the use of better piston materials and improved conrod bearings. The latter are usually phosphor-bronze bushed at both ends and, in one or two cases (e.g. Merco and O.S.), the piston bosses are also bronze bushed.

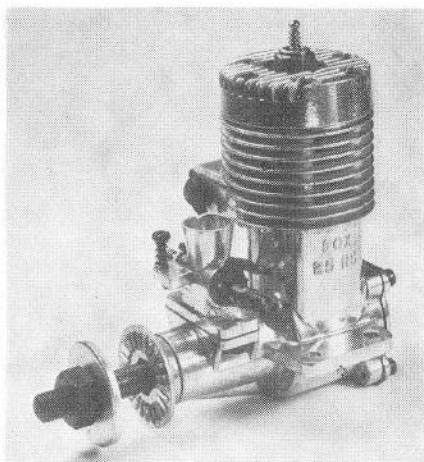
Some of the qualities of the better 60's are now beginning to spread to the leading front induction twin ball-bearing, ringed piston 40's such as the redesigned O.S. Max 40 R/C which was first marketed in the U.K. in the spring of 1973. Engines of this type, which also include the Webra 40, K&B 40F, HP 40F and Super-Tigre G.21/40FI, are now becoming widely used by club flyers for aerobatic models. While a 60 remains the favourite for competition flying, the top 40's are capable, in a slightly smaller and lighter model, of giving a performance that is comparable with that of a 60 powered machine at considerably reduced cost —i.e. smaller initial outlay for model and engine, accompanied by lower fuel consumption.

These engines are not, of course, to be confused with the pylon-racing 40's. By common consent, all the most widely favoured aerobatic 40's are of the shaft rotary-valve type at present, whereas the most successful pylon motors have rear-induction. Furthermore, pylon racing rules (or perhaps one should say the lack of them) have reduced the throttle control to nothing more than a cut-out device so that, with its vast unrestricted air intake, the modern pylon-racing engine is more akin to a control-line speed motor. It develops its peak output at 20,000 r.p.m. or more, which is well suited to tiny racing props but is unusable with the larger diameters and bigger blade areas necessary for pulling an aerobatic model up vertically. The neces-

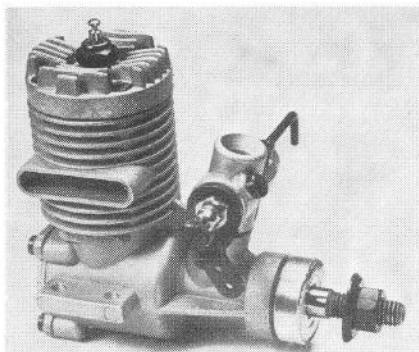
sary differences between the two types of engines are that the racing 40 is required only to develop as much power as possible under an almost constant load (i.e. flat out straight and level flying with only slight increases in load on take-off and through turns) whereas the aerobatic 40 must cope with wide variations in load and should also be capable of being safely throttled down and opened up again over, say, a 2,500-14,000 r.p.m. speed range irrespective of the model's attitude or the level of fuel within its tank.

Finally, we come to our 'Trainer and General Purpose' group. A few years ago this category would have included a fairly large proportion of small diesel and glowplug engines, with simple throttling devices, aimed at the 'bang-bang rudder-only' flyer. Beginners started with single-channel sequential-control equipment and, with a full-house reed outfit costing £150 or so, a lot of them stayed with single-channel and the low-powered models that went with it.

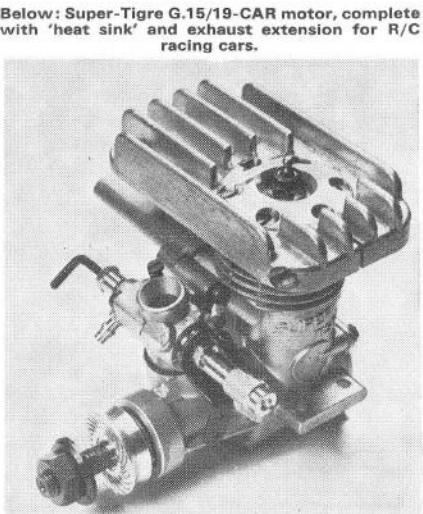
Nowadays, with proportional equipment so very much cheaper, the trend is away from the slow 'interrupted



The low-priced Fox 25 R/C has a capacity of 4 c.c. and is simple, light and powerful.

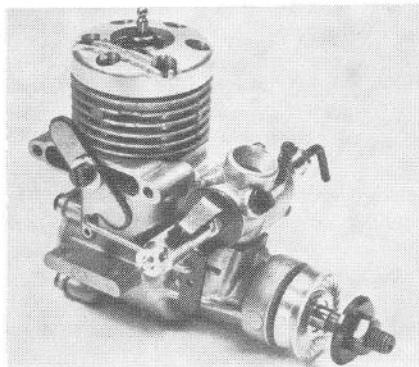


Above: Italian Kosmic K-23 is produced by Komet Kart engine manufacturer. Well made with neat automix carb.

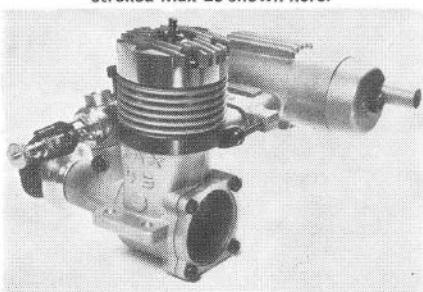


Below:

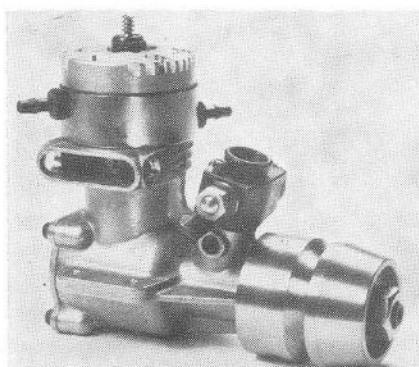
Super-Tigre G.15/19-CAR motor, complete with 'heat sink' and exhaust extension for R/C racing cars.



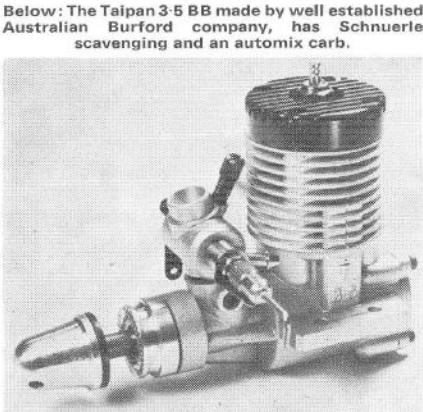
Above: one of a famous family, the R/C version of the popular Super-Tigre G.15 F/F and C/L engine.



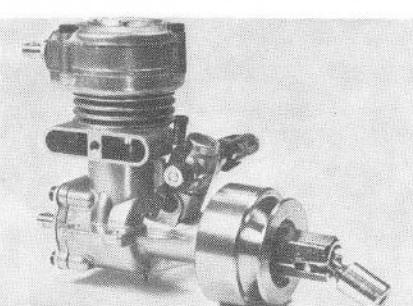
Below: Popular trainer engine is O.S. Max 20. Having same external dimensions is bored and stroked Max-25 shown here.



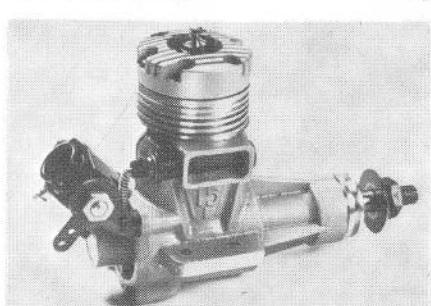
Above: German made version of Veco 19 is available in four types. This is the marine R/C model.



Below: The Taipan 3.5 BB made by well established Australian Burford company, has Schnuerle scavenging and an automix carb.



Available for several O.S. engines is conversion set for watercooling head and crankcase. Shown here is marinized O.S. Max-10.



New K&B 15R engine with Perry carb is No. 1 contender for 'Quarter-Midget' pylon-racing honours.

free-flight' type of model and towards heavier models requiring more powerful engines. R/C trainers are commonly powered with engines of between .19 and .35 cu. in.

One of the most popular of these 19s, for many years, has been the 3.2 c.c. O.S. Max-19. In 1971 this was superseded by an entirely new model of similar size, the Max-20 and, based on the same main casting but having its bore and stroke slightly increased to raise its displacement to .25 cu. in. or 4 c.c., is the Max-25. Like all current O.S. motors, the 20 and 25 are each sold complete with a silencer and are proving very popular. The 25 size was also taken up by the American Fox company at about the same time and, like the O.S., the Fox 25 offers the advantage of a lightweight compact power unit (overall sizes and weights are much the same as for the average 19) in which the extra swept volume amply compensates for the power lost when the engine is fitted with an effective silencer.

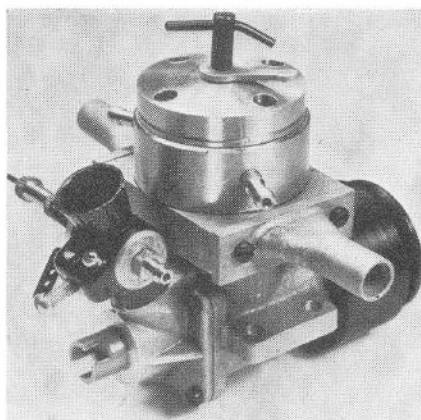
Other newcomers (1972-73) include the German HB 20, the Italian Kosmic K23 and the Australian Taipan 3.5. The HB is a development of the American Veco 19 (which HB also manufacture using U.S. castings) and like other HB engines, is fitted with a German made version of the American Perry carburettor. The Kosmic (.22

cu. in.) is made by the manufacturer of the Komet go-kart engines and is obviously intended to compete with its well-established compatriot, the Super-Tigre G.20/23 which, internally, it resembles quite closely. Incidentally, the Super-Tigre has been considerably improved and now includes a Super-Tigre Mag type carburettor with automatic mixture control.

The Taipan 3.5 (.21 cu. in.) is unusual among engines in this class in that it features Schnuerle scavenging and is available in a choice of two models, one with a bronze bushed main bearing and one with twin ball bearings. The Taipan is somewhat heavier than the others of this group but is very sturdily made and should be able to take more than average punishment.

Most of the engines in the .29 to .36 cu. in. group have been with us for some time but there are new Fox 29 and 36 R/C engines which are remarkably low-priced for motors of this size. They both have a bronze bushed main bearing and feature a special Fox carburettor with separate idling and high-speed jets. Incidentally, all the Fox engines are now very reasonably priced in the U.K. thanks to a special Fox marketing set-up and the Fox Falcon 60 is by far the cheapest large R/C engine now available.

Among the smaller sizes, the O.S.



E.D. Sea-Lion 5 c.c. diesel, intended solely for marine use, has rear drive take-off and, of course, water cooling.

forward on the front of the ball-bearing mounted crankshaft for ease of starting. The engine includes a barrel throttle carburettor and, like its predecessor, the E.D. Viking, its internals are based on the well-tried Miles 5 c.c. diesel.

Marine versions continue to be made of the British Merco 29, 35, 49 and 61. The major American engine manufacturers do not offer water-cooled versions of their engines but Irvine Engines, the U.K. importers of K&B, offer their own excellent marine conversions of the K&B 15, 35 and 40 models.

Certain O.S. Max units, including the largest (Max-H.80) and smallest (Max-10) are available in water-cooled versions. These have special watercooled cylinder-heads (and, except for the 80, watercooled crankcase backplates) that are interchangeable with the aircooled components. Conversion sets are also obtainable enabling the owner to utilize one engine for both aircraft and boat use if he so wishes. Flywheels for O.S. engines, sold by the U.K. distributors (Keilkraft) are made in Britain.

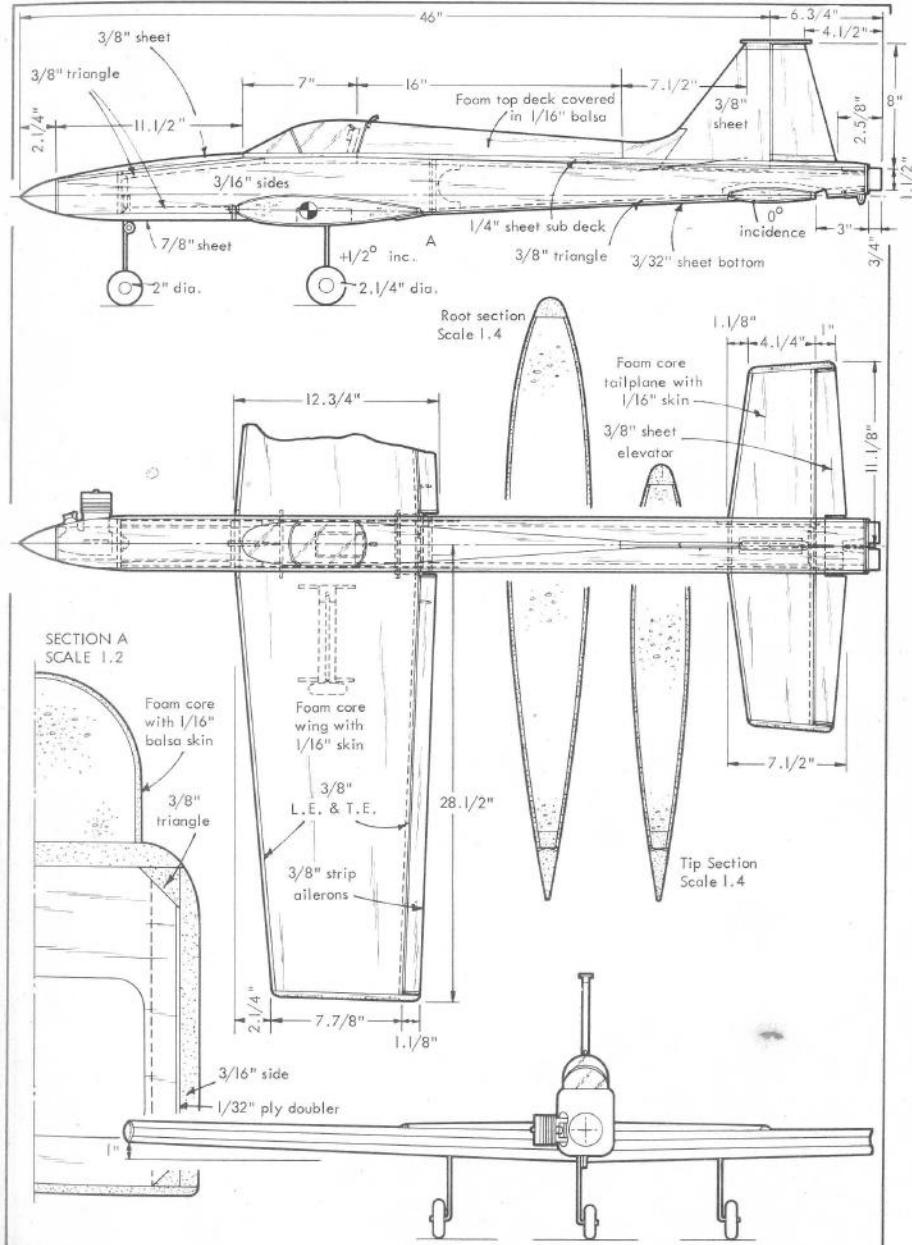
Most other makes have fixed water jackets. They include nearly all the engines in the Enya range, some Webras and Super-Tigres and all the HB and 'Europe Series' Veco models. The HP 40 and 60 engines, both front and rear induction are also produced in watercooled versions as are the Kosmic K-15 and K23, the Rossi 15 and 60 and all the OPS models.

Finally, a word about marine R/C motors, of which a much wider variety is now available. Most of these are watercooled versions of existing aircraft engines but there are a few that have been especially designed for boats, notably the compression-ignition units offered by E.D. Ltd. of Surbiton. E.D.'s recently introduced Viking 5 c.c. watercooled diesel has a special rear drive take-off for the propshaft, the flywheel being installed

All the engines we have mentioned in this article are either available now in the U.K. or are expected in the immediate future. The British R/C modeller has an immense range of engines from which to choose—a wider selection, perhaps, than anywhere else in the world.

Tiger Panzer

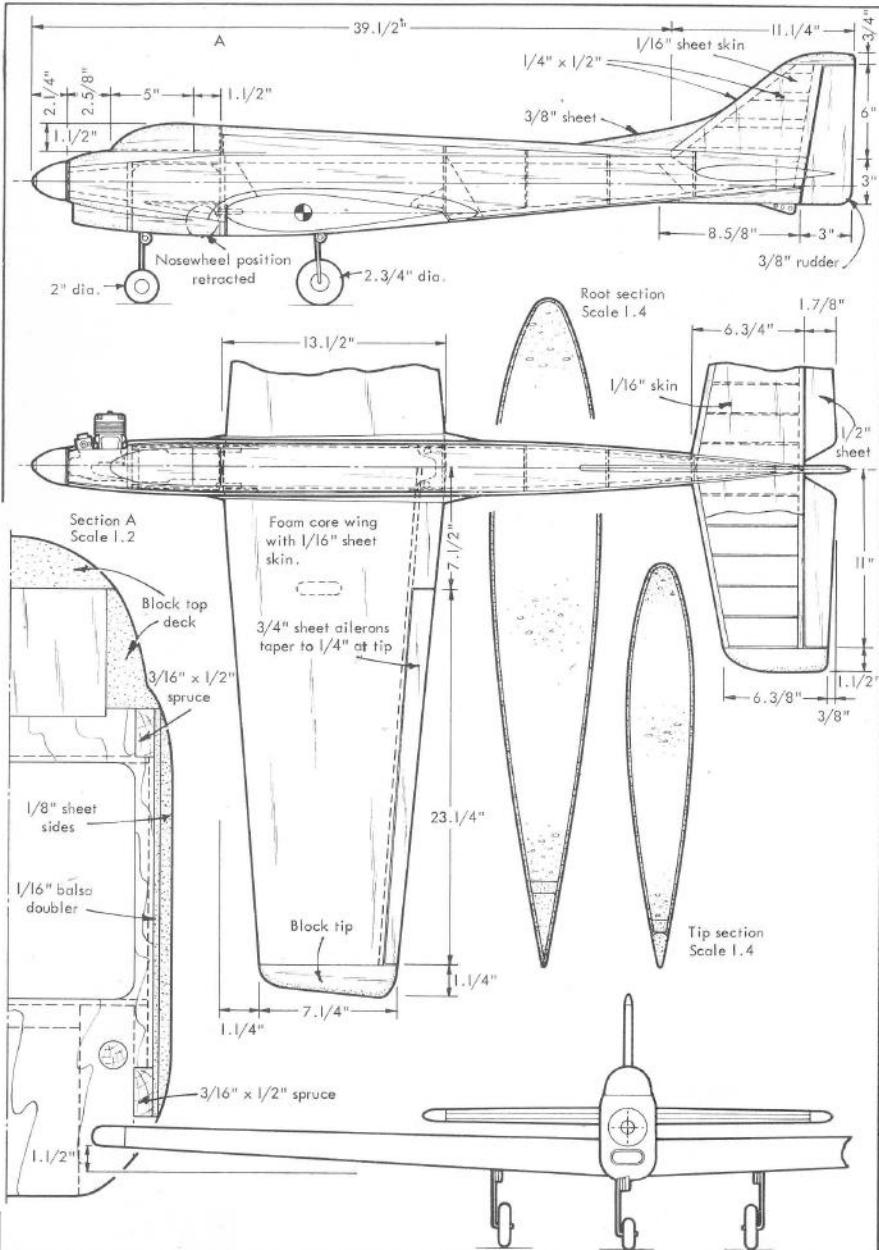
10 c.c. powered F.A.I. class aerobatic model
BY RICH BRAND



Swea'tater

10 c.c. aerobatic model
for full house R/C
BY DON COLEMAN

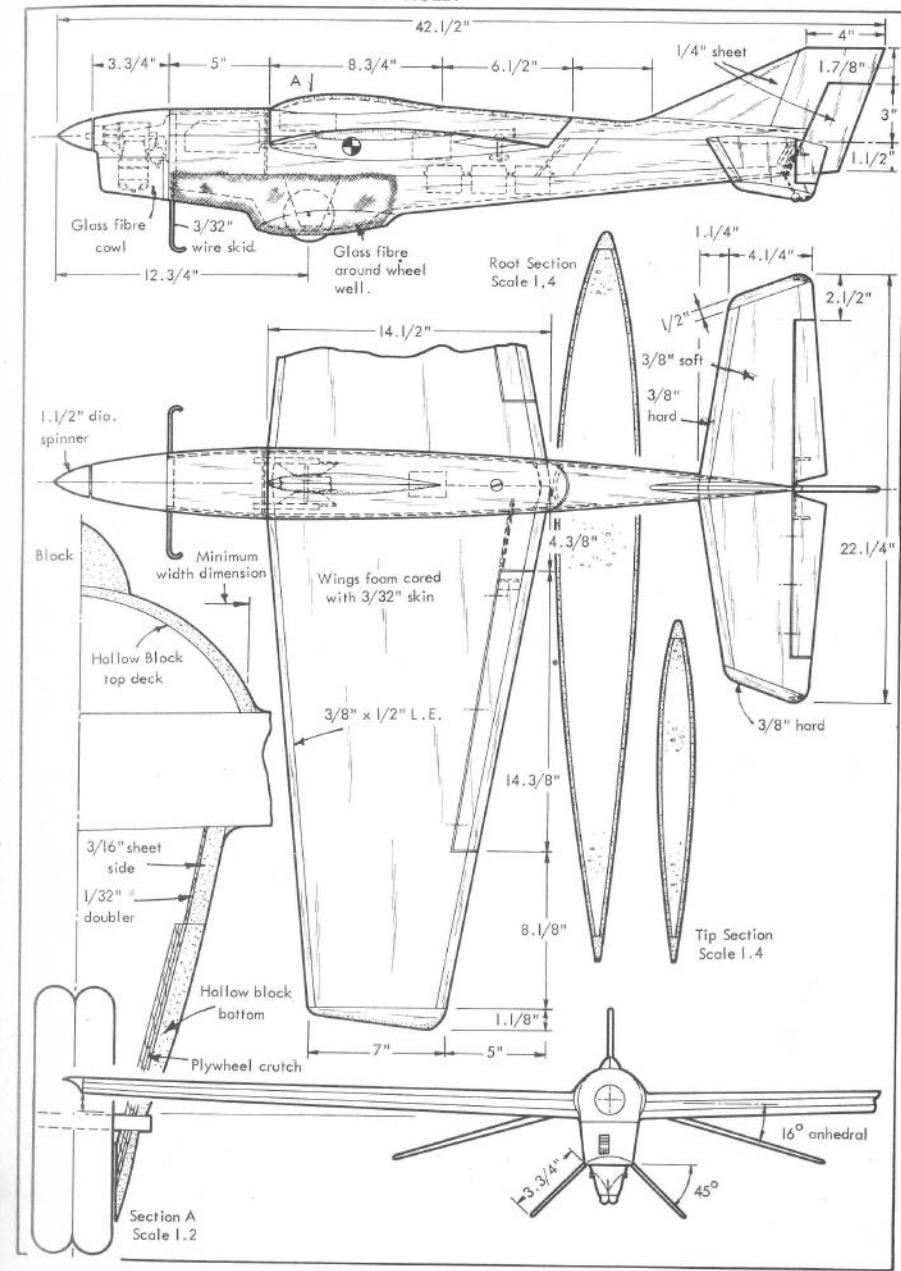
Scale 1:12



Bob Cat

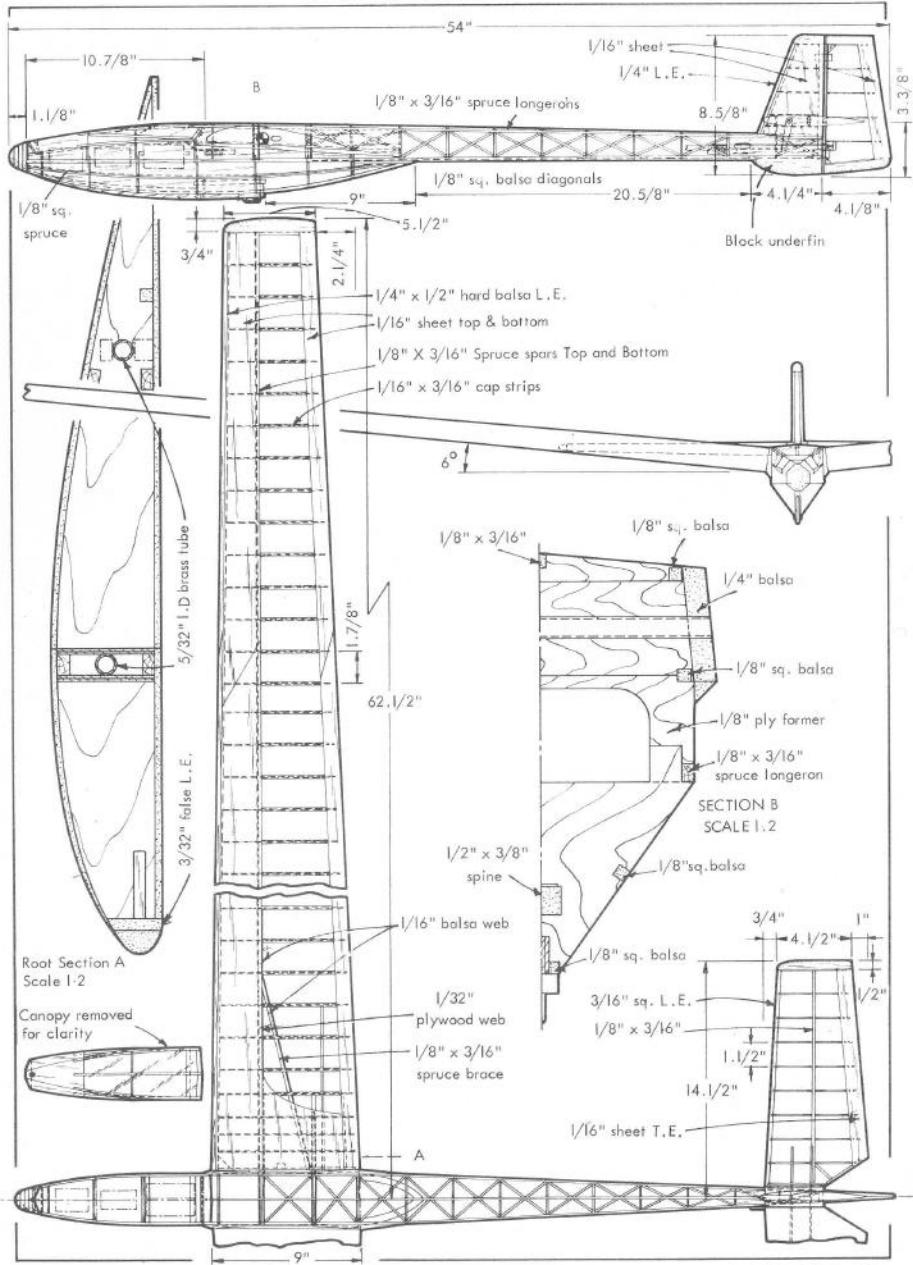
**F.A.I. Class Pylon Racer. Winner of 1972
Cranfield International and 1973 U.S. Nationals
BY BOB VIOLET**

Scale 1:10

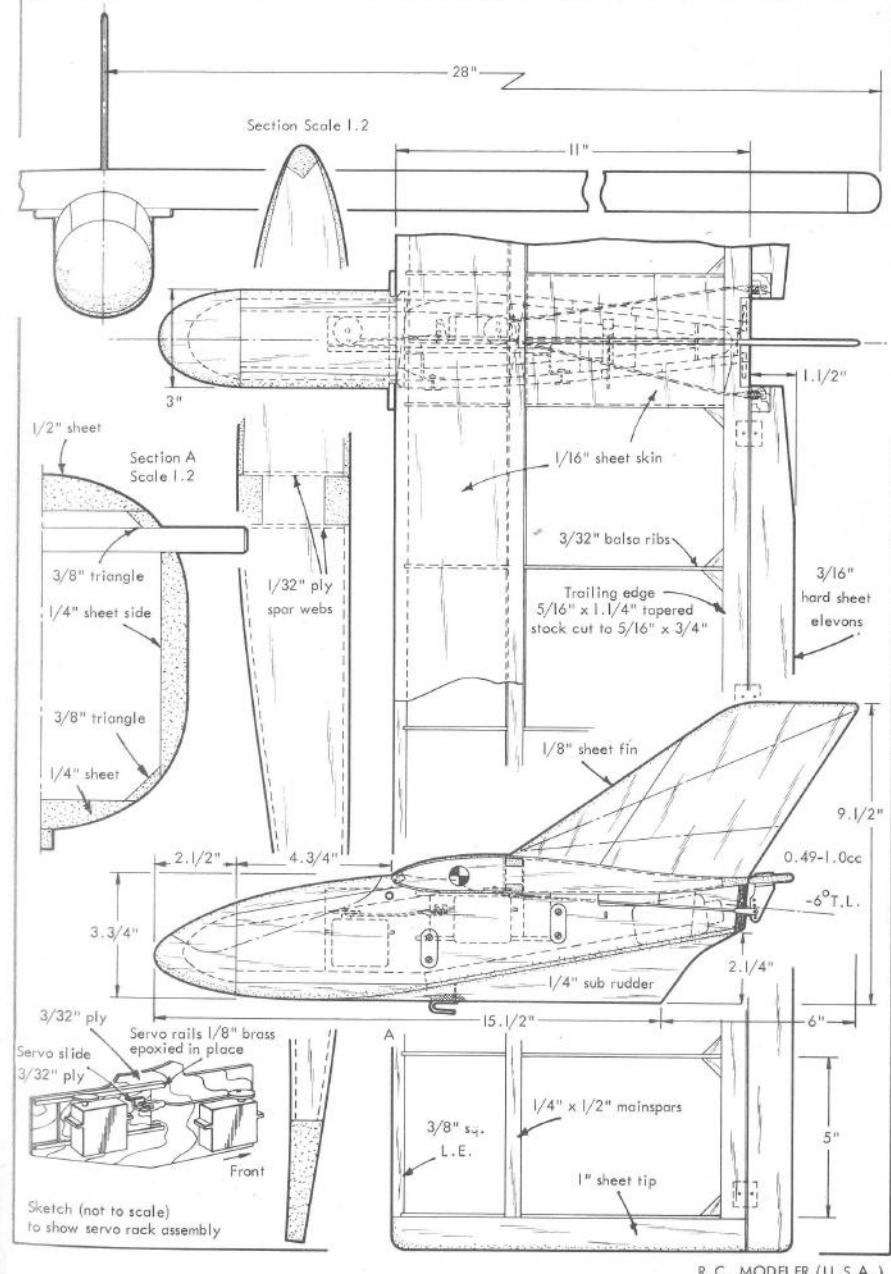


Snoopy

Contest winning R/C Thermal Soarer.
1973 U.S. Nationals Winner.
BY OTTO HEITHECKER

**Little Plank**

Simple flying wing slope soarer with power option.
BY CHUCK CLEMANS & DAVE JONES



THE ELECTROSTATIC AUTOPILOT

By Maynard Hill

FANTASTIC! Spooky! Unbelievable! Amazing! These are a few of the adjectives that have been used by some pilots who have flown radio-controlled airplanes fitted with a new type of stabilising autopilot that uses static electricity in the atmosphere as a reference signal.

'How does it work? How did you ever think up a system like that? What does it cost? Will it work on a metal airplane or a light aircraft? How much does it weigh? Are there any moving parts? Will it work on a Helicopter? Is it good for pylon racers?' These are some of the questions that follow the adjectives.

The device is not a mysterious 'spooky' divining-rod type of thing. Neither is it a fantasy. It is real, it works, and it's based on scientific knowledge. The only unbelievable aspect of it is that there apparently has been no prior attempt using this particular combination of physical phenomena in a practical device for aircraft stabilisation. In fact, there has not been much exploitation of any of the voluminous research that has been performed in the field of atmospheric electricity during the past two centuries.

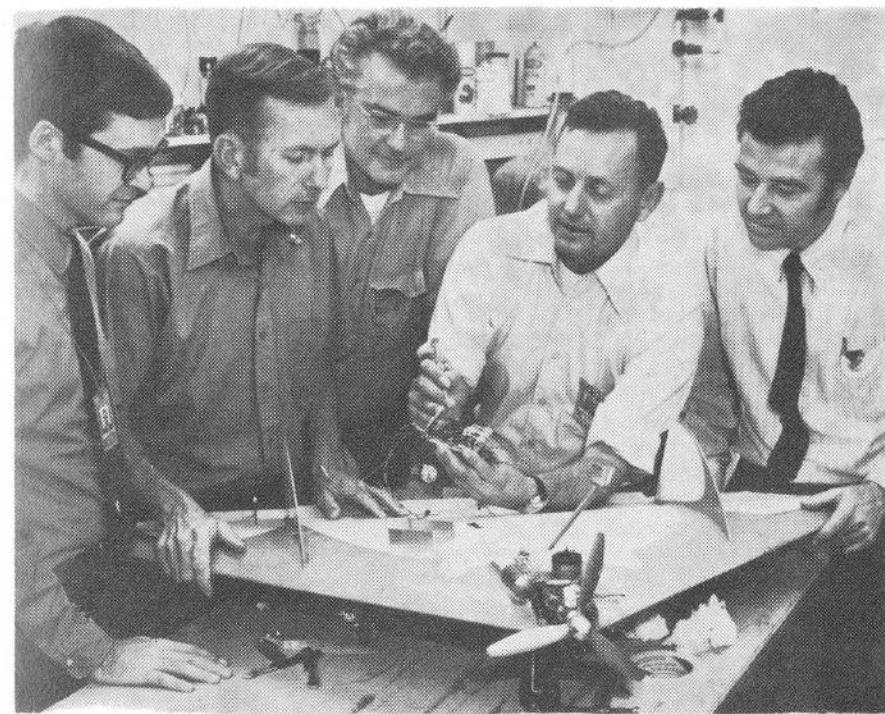
The electrostatic autopilot consists of a patch of harmless radioactive material mounted on each wing tip and on the nose and tail of an aircraft along with two highly sensitive differential voltmeters. As an end product, a stabilisation system has been developed which, under the conditions that we have flown, appears equal to

the capabilities of conventional systems employing precision mechanical gyros.

The operating principles of the system are based on two key facets of atmospheric electricity that have been known for a very long time. One is Benjamin Franklin's demonstration in 1752 that lightning transfers large amounts of negative charge to the Earth. The other is Lord Kelvin's analogy, proposed in 1860, that the atmosphere is like a large capacitor where there is a highly conducting layer in the upper atmosphere that acts like a highly charged positive plate, while Earth acts as the negative plate of the capacitor. Through some unusual but very enjoyable experiments, new insight has been added to the 'capacitor idea'. We have shown that there are voltage levels within the atmosphere that are almost as smooth and horizontal as the equipotential planes seen in sketches in college text books describing the electric field between capacitor plates. The reference signals for stabilisation are derived from measurements related to these equipotential planes.

Let's answer some easy questions first. The two-axis stabilisers that we've flown weigh about 3 ounces. There are no moving parts in the sensor system. There are about fifty dollars worth of electronic components in our present autopilot design, but the real cost is yet undefined.

How did you 'think up' such a device? The answer here is that the



Some of the people who participated with Maynard Hill in development of system. Left to right: John Rowland, Robert Givens, Ray Cole, (Hill) and Chris Keller. Model is Talon Zephyr delta.

device was not thought up. A unique set of circumstances involving seeing, hearing, doing and thinking led to recognising the possibilities of developing such a device. The combination that occurred was that a metallurgist with a good sense of musical pitch who had obtained a practical education in aerodynamics, control systems and metereology through an avocation of flying model airplanes was outdoors providing some 'flight service' to test an unusual instrument designed to study clear air turbulence. With such an unlikely list of prerequisites, maybe it does make sense that it took so long to discover static voltage stabilisation.

The experiment we were doing had been devised by John Rowland, a colleague at the Applied Physics

Laboratory, who has a dedicated interest in learning about clear air turbulence created by thermals. During the past two years, we have worked together on a project in which we have used radio-controlled airplanes to make specialised soundings to measure air properties within thermals detected by large radar systems at Wallops Island. A photograph of the 'Catbird' one of the airplanes we have used a great deal is shown among these pages. This model is a beefed-up version of typical radio aircraft that have been used by the writer to set altitude and duration records.

A new kind of instrument for possible use in finding thermals was being developed. The idea was that thermals often pick up dust particles which could be charged with static electricity. A sensitive differential voltmeter was to be installed in the

wing of an airplane. An audio tone being telemetered from the airplane was expected to play a high musical note if a thermal was on the left and a low tone if the thermal was on the right side of the aircraft.

In the March 1969 issue of *Flying Models* the author and Ben Givens reported a telemetering device for radio-controlled soaring gliders that tells a pilot on the ground when his model is in an updraft. This sensitive vertical velocity meter helped significantly in establishing a world altitude record of 3,680 feet for soaring gliders back in 1966. Many glider guiders use the 'thermal sniffer' today to improve their technique of soaring. Highly calibrated versions of the same type of vertical velocity meters have been of valuable use in the clear air turbulence studies being conducted at APL. But the device has a drawback. It can only tell you when the model is in a thermal. It cannot tell you which direction to fly in to find a thermal. Now John Rowland was proposing a device that might do this. It sounded like a great idea.

We installed the system in the wing of the battered but flyable 12-foot-span 'Bong Boomer' (*Flying Models*, February 1967) glider and fitted it with an engine to make the job easier. Several flying sessions were carried out during which we reached no conclusive results about thermal sensing. Tone variations were small and did not fit any consistent pattern when we flew near suspected thermal areas. A hard landing on a windy afternoon brought us, to a standstill. It appeared that horizontal voltage gradients due to thermals must be fairly small in magnitude. The attempt to develop a thermal direction finder was temporarily abandoned.

From my position in the 'pilot's seat' I came away from these flights with a suspicion that the vertical voltage gradient was always much larger than

thermal effects and that there was a systematic relationship between bank angle and the voltage being generated in the sensor system. Soon the rig was installed in another model designed to withstand more aerobatic violence than the one we had just damaged. A few hammerhead stalls and full rolls gave further strength to the suspicion. A quick trip to the shop was made to change some resistors and install a couple of capacitors to try to improve the sensitivity of the TM signal. By the end of the day it was clear that there was indeed a signal that very much resembled what one would expect from a vertical reference gyro. The pitch of the tone was remarkably steady during level flight. Slight banking turns of the right produced a mild upward shift in pitch and steep turns produced a beautiful high squeal. A low groaning tone accompanied a steep left turn.

A period of feverish flight activity followed during which the telemetering unit was flown in winds up to about 25 m.p.h., under low overcast skies, in a drizzle, in smog, near thunderstorms, and on two occasions into the base of heavy clouds at about 600 feet altitude. Ben Givens was especially helpful during this period. A tape recorder was always present taking down audio tones and comments by the pilot about the attitude of the aircraft. Flights were made with sensors mounted both for pitch and roll measurements. The audio tapes always fortified the conclusion that the voltage being produced was highly proportional to the attitude of the aircraft. The magnitude of the tone shift seemed very reproducible and noise-free regardless of the weather and time of day. Gusty winds did not seem to destroy the relationship between bank angle and tone frequency.

Ben and I spreadeagled the innards of the TM set and several Kraft servos

out on a workbench. Measurements and adjustments were made, wires were strung and a switch was installed so as to be able to connect the generated signal to the aileron servo by command from the ground. We found a place in the servo where the feedback loop could be closed while still providing a capability for the pilot to override the 'stabiliser' with the control stick.

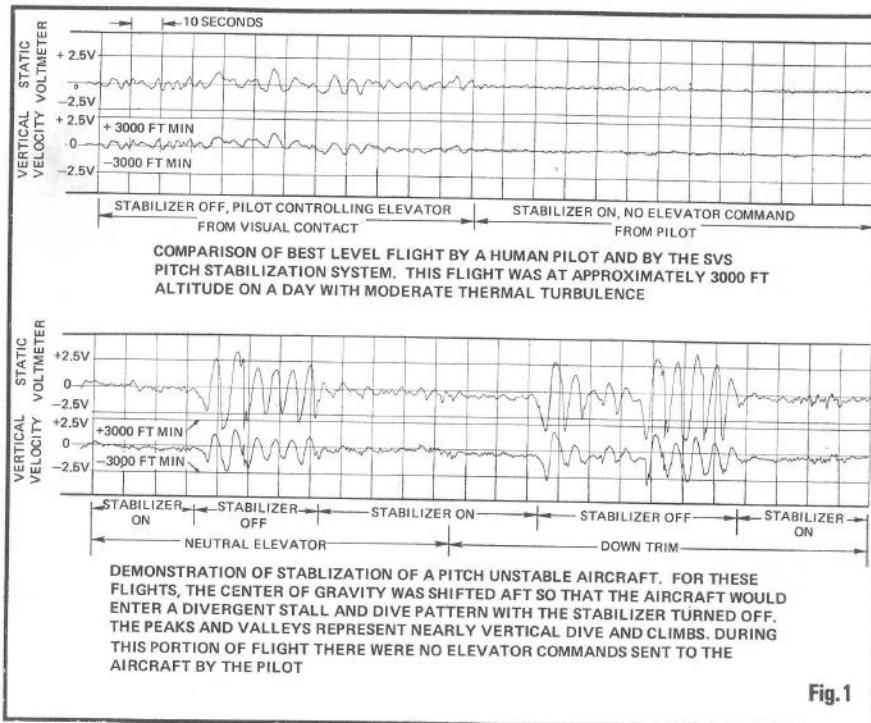
It is a thrilling experience to land a radio-controlled model aircraft directly in front of certifying officials after flying it to a world record altitude of 27,000 feet. A half hour earlier it had been but a small speck in high powered telescopes and the slightest malfunction would have meant total loss. Many other similar moments of satisfaction have occurred during my 38 years of aeromodelling. Some of the best 'kicks' have come from private little experiments that turned out wrong for practical use and right for learning something new. Other 'kicks' have come from such public spectacles as flying a radio-controlled model across the state of New York for a distance record. But none of the thrills has equalled the feeling that came when that stabilizer switch was first activated. The control transmitter had been trimmed to produce a condition of instability such that, in a 'hands off' condition, the airplane quickly rolled over into a steep descending spiral dive. Activation of the switch snapped the wings back up to a level position! 'Wow! Look at that!' was recorded on the tape recorder at over 100 decibels.

At first, it felt uncanny to be able to forget about giving roll commands. The airplane would fly hands off and return to level after every gust disturbance. We soon learned to trust the stabilizer. We could set the transmitter on the ground and watch the airplane fly across the sky. Full 'hard over' commands would result only in a very smooth graceful turn of constant and

shallow bank angle as contrasted with vicious spiral dives or rolls that would occur without stabilisation. Even a *Tiger Tail* can be tamed to have *Rudderbug* flying qualities.

It wasn't very long before we had the elevator servo of the *Catbird* responding to the nose probe and a second electrode mounted on top of the vertical fin as seen in some of the photos. The extended nose probe was used to prevent engine oil from getting on the front radioactive source. The sources are a polonium isotope that emits only alpha particles. These are stopped by thin plastic films or other organic films such as castor oil. There is no physical hazard from such polonium sources so long as the radioactive material is not ingested, and the units are normally supplied with a metallic grid to prevent this from happening accidentally. Incidentally, these radioactive sources can be bought in many record shops. They are attached to a paint brush type of deal that eliminates static electricity and lets you brush the dust off the record. If you buy one, read the instructions which advise you to keep them out of reach of children.

The demonstration of pitch stabilisation was even more dramatic than in the earlier case of roll. The centre of gravity of the aircraft was moved from its normal point of 25 per cent of the wing chord back to about 50 per cent by putting a crescent wrench in the tail section. This converted the airplane to a 'real dog'. In the 'hands off' condition, the aircraft would enter a divergent phugoid that eventually built up into a sequence of violently steep dives followed by vertical climbs with vicious stalls and 'flip over' loops at the top. The telemetering signal sounded like a police siren! Activation of the switch resulted in almost immediate return to level flight and a pleasant steady tone from the TM.



Gusts were seen to lift the nose temporarily, but the feedback loop quickly returned it to level.

The pitch stabilising system was used operationally during two weeks of data flights at Wallops Island, Virginia and numerous quantitative telemetry records about its performance were obtained during about 10 hours of flying time. We found the stabiliser very useful in this CAT experiment in which one of the objectives was to measure vertical velocity of a thermal updraft. The procedure called for flying to about 4,000 feet altitude (in a restricted air space), shutting off the engine and gliding back down at minimum sinking speed of the aircraft. Under these conditions, the aircraft sinks at about 4 ft./sec. and vertical up-draft of this order or magnitude can be detected. But there has always been a tendency

of the aircraft to swoop up and down mildly during this procedure. It is particularly difficult at altitudes above 2,000 feet for the pilot to see the small motions of the aircraft well enough to apply the necessary elevator commands to prevent all phugoid motions. The data on thermal velocity are complicated by these extraneous motions. Thus, smooth flight is very desirable. A typical TM trace, seen in Figure 1, shows that the autopilot obviously provides smoother flight than can a pilot on the ground. The bottom half of this same Figure shows how the stabiliser grabs hold of a tail-heavy airplane and makes it fly level.

A roll-axis stabiliser was next installed in the 44 in. span *Talon Zephyr* delta shown in some photos. It just seemed that things were going too well and we had to find some more severe tests to demonstrate that there

were some real problems with the new autopilot. The Delta seemed like an appropriate challenge as this kind of aircraft is unstable and hard to fly. We fully expected that if the stabiliser worked at all on this 'skittish' model we would probably see it oscillate badly in roll as the stabiliser tried to keep it level. But another momentous thrill came when the stabiliser switch was activated. Again, the aircraft snapped to level flight and took on characteristics of a boat skimming along the surface of the water. Normally this command would produce a continuous roll at a rate of about 360° per second, but now the pilot could remove his hands from the control stick and, providing the elevator was properly trimmed, the model would pop to straight and level flight and maintain a course that gave the impression it would like to go right out over the ocean and land at Paris!

This same Delta was soon fitted for simultaneous pitch and roll stabilisation. Again, the nose probe in front of the propeller was used, as seen on the cover. The fact that this probe is elevated about 8 inches above the wing tip probes has a special benefit in that it automatically couples some up-elevator with roll when the craft rolls to a banked turn. The result is that this airplane does coordinated turns and is almost as easy to drive as an automobile. My wife, Gay, has tried on several occasions to fly some tame models, but she has never had much success. To prove that this new system will permit a novice to fly, she took the control stick and was instructed only to (a) push the stick left to turn left, (b) push right to go right, and (c) let go of the stick if you get confused. She managed to run the airplane out of fuel. This performance was observed by members of the DCRC Club, and a controversy has arisen because, at the Club's annual family

picnic, there is usually an event called 'Divorce R/C Style'. The object is for a husband to give his transmitter to his wife, and the time is measured until the husband grabs the transmitter to prevent a crash of his model. The DCRC picnic organisers are rumoured to be writing a rule against autopilots!

The Delta model is a good demonstration vehicle because without stabilisation, it will quickly roll and dive towards the ground if the pilot takes his hands off the stick. Subsequent turning of the stabiliser, however, results in very abrupt pitch and roll manoeuvres to bring the craft to level cruise attitude. If the model is rolled over inverted and then the pilot turns on the stabiliser and releases the stick, the aircraft quickly rolls or pulls a loop to get into the upright position. It is impossible for the pilot to hold the airplane inverted once the stabiliser is on. Automatic 'hands off' landings have been done with this delta using only the throttle to control the descent rate. Stabilised takeoffs from a paved runway have also been performed but we have encountered some unusual effects in taking off from grass fields. Evidently a blade of grass hitting one or the other sensor can impart a quick roll command as the craft is about to depart the ground. We have stabilised a *Tiger Tail* so that it flies inverted with 'hands off' the transmitter. We need a new record category—the longest sustained inverted flight. It would be easy with the device. You can set the transmitter on the ground and watch the model fly inverted.

It is not extremely time-consuming or difficult for skilled aeromodellers to reproduce this device and test it. For example, circuit diagrams and a description of the principles were given to Don Lowe and Dennis Ingebretson who run a project using radio-controlled model techniques for research at Wright-Patterson Air Force

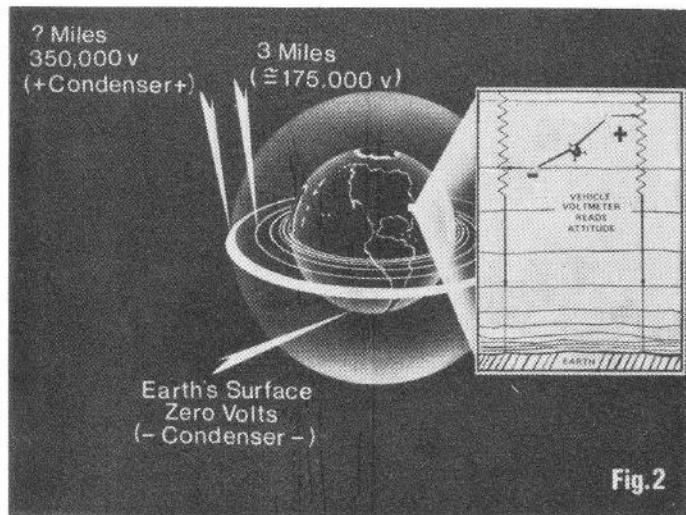


Fig.2

Base. Six days after receiving the information Don and Dennis called to say they had successfully flown the device 'two days ago on a day when there were thunderstorms nearby.' It worked the first time they tried it. This group has progressed rapidly and has done night flying and automatic landings with *Ugly Sticks*, *Big Daddies* and several other unusual airplanes.

Theory and Background

It isn't necessary or appropriate here to go into great detail to explain the physical phenomena of the atmosphere from which the signals are derived. If you are curious there is a brief description about atmospheric electricity in the November 1972 issue of *Astronautics and Aeronautics*, a magazine published by the American Institute of Aeronautics and Astronautics. This can be found in most all technical libraries. If you really want to study the details, there is an excellent book by J. A. Chalmers called '*Atmospheric Electricity*' published by Pergamon Press, 1967, and available in technical book stores.

A very simplified atmospheric model

that helps explain the operation of the autopilot is shown in Figure 2. The air above Earth is like a huge twin-shelled spherical capacitor. The upper plate is some 20 or more miles high and consists of a highly conductive layer of air that is ionized by cosmic and solar radiation. The upper plate is charged to about 350,000 volts. The Earth's surface, which is also an excellent conductor, serves as the other plate of the capacitor.

The most widely accepted theory holds that thunderstorms maintain the charge on this capacitor. It was Ben Franklin who first pointed out that lightning typically puts negative charges onto the earth and it was Lord Kelvin who first suggested that the atmosphere can be likened to a spherical capacitor. Because both the upper air and the earth are highly conducting, lightning discharges that occur in Europe and Africa quickly spread to a uniform voltage over the whole globe. So when you are out flying an electrostatic autopilot on a clear Sunday morning you may actually be using power from lightning that is striking the Alps during a late after-

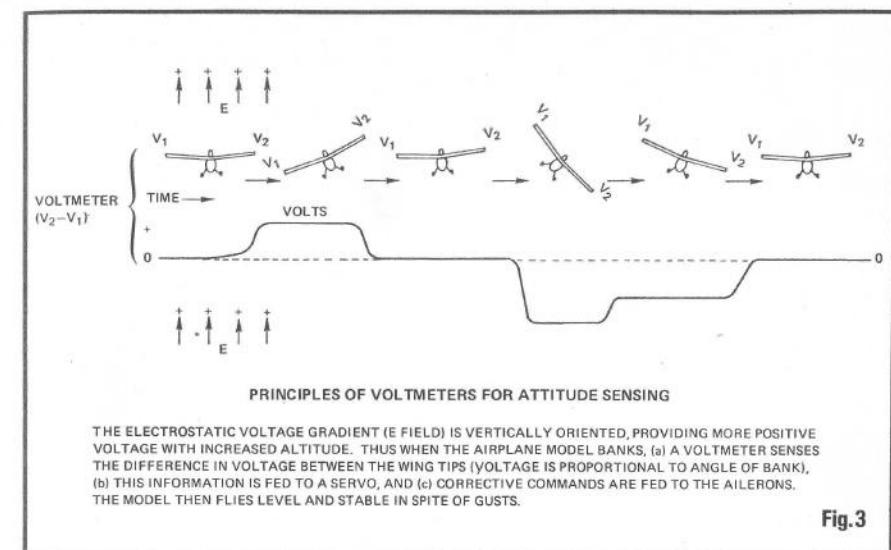


Fig.3

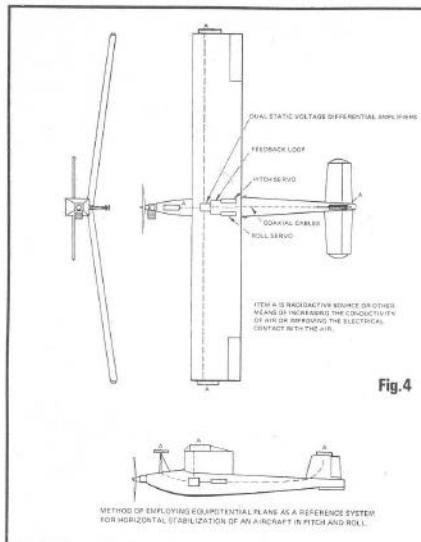
noon thunderstorm. It is interesting to note that there are about 630 megawatts of DC power continuously flowing down through earth's atmosphere. That's enough power to light up a fair sized city!

But do not get too concerned about such details. The voltage on the capacitor seems to be there on any day that it is reasonable to go flying radio-controlled airplanes. It's been measured for the past 150 years and hasn't disappeared, so we can probably count on it for the future. The gradient sometimes gets fouled up in snow storms and heavy rain, but it has been found pretty reliable in clear to mildly foul weather.

The voltage gradient is usually very strong near the ground where we fly R/C models. Typically it is about 180 volts per meter. That means that when you stand in an open field, your head is poked up at a point where the voltage is about 300 volts higher than your feet. If you stretch your arm vertically it reaches up to a point where the voltage is normally 400 volts positive. The antenna of your transmitter might see 600 or 700 volts.

Except for the fact that the current that is available is extremely minuscule, you'd be dead long ago! But you have to believe this. When your R/C model banks to 45 degrees, the high wing tip would typically be 60 to 80 volts more positive than the low tip. This kind of signal is easy to pick up with the sensitive voltmeters shown here.

The principles of the sensor system can be visualized from Figures 2 and 3 where a radio-controlled airplane is shown to be flying at various bank angles to the earth's surface. The low wing picks up a negative signal while the high one gets a positive signal. We take the difference between these signals and connect the result to the servo system so as to provide the same servo motion that you as a pilot ordinarily would apply to the transmitter to bring the airplane back to level. The voltage gradient is everywhere in the sky, so it is as though the wing tips are attached to potentiometers that fly through the air with the airplane. If we also put a pair of sensors in the fore and aft direction as shown on Figure 4 we can also control the craft to keep it level in

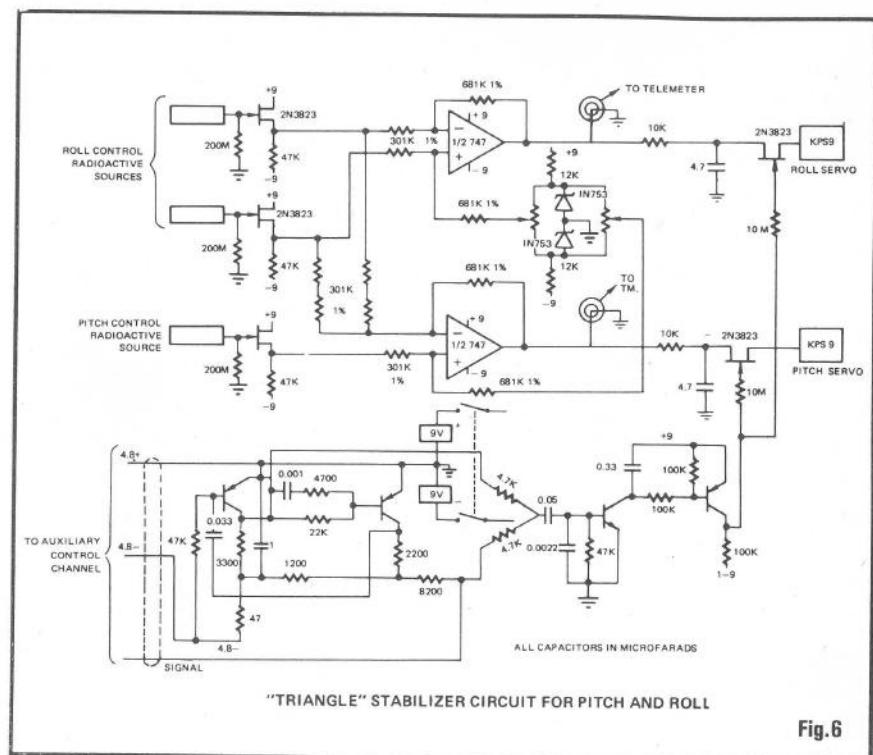
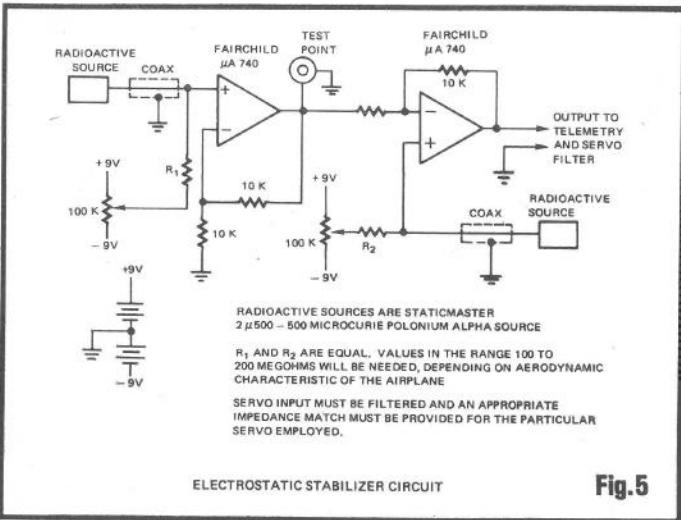


suitable for large slow airplanes such as the Catbird is shown in Figure 5. Figure 6 shows a special 'triangle circuit' that was developed by Ben Givens and which has been used on the Delta and conventional aircraft for providing pitch and roll stabilisation. This circuit includes an electronic switch for activating the feedback loop. This switch can be plugged into a spare channel and it is recommended that you don't turn it on for the first take-off. Only three radio-active electrodes are needed for this triangle circuit: one on the nose of the Delta (or vertical fin of a conventional aircraft) and one on each wingtip. The nose (or tail) probe is referenced to the electrical centre of the two wingtip electrodes.

The output of the differential voltmeters must be appropriately impedance matched and fed into the timing circuit of the 'one shot' generator in the servo. A diagram of how to do this on a Kraft 3-wire IC servo is shown in Figure 7. We haven't done this to any other type of servos, so we can't give instructions for other systems. You could ask the manufacturer how to do this on your set or

pitch. When both axes are stabilised, presto! you have a model that will 'zap' to level flight any time you let go of the stick. It will even recover from inverted spins automatically and come out flying upright and level with your hands off the control stick.

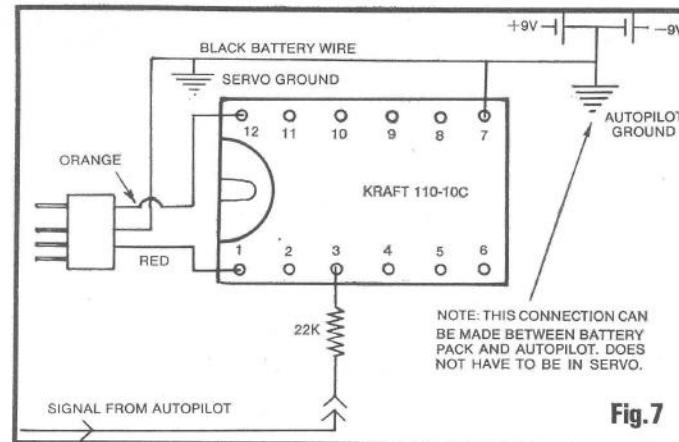
A circuit diagram for a single-axis attitude sensor (voltmeter) that is



ask some experienced electroniker for help. Needless to say, this is not a project for a neophyte experimenter. There are some pitfalls that need to be thought through. Like for instance, don't put this system onto a servo that

will strip its gears if it goes out against the stops. You will need additionally circuitry to prevent this if you don't use something like Kraft KPS-9's which tolerate this brutality.

There is a simple but reliable test



to assure that the controls go in the proper direction to right the aircraft as opposed to turning it inverted. A hard rubber comb, brushed through the hair takes on a negative charge. When this negative charge is brought next to a wingtip, the aileron should deflect downward to produce extra lift, as this represents a wing that is inclined downward towards earth in flight. The elevator should go up when the comb is held at the nose of the aircraft. In an open field, the surfaces will respond to bank and pitch motions if the model is lifted off the ground and rotated. The amplitude of the response is not as large as when airborne, but the test is satisfactory for demonstrating that the system is operational. The comb can be used anywhere, but there will be no response to rotation indoors, under trees or near tall buildings because of electrostatic shielding by these objects.

Measurement in R/C Airplanes

Sections of telemetering records taken during soundings and test flights of the Catbird airplane are shown in Figure 1. For these tests, the airplane carried a 5 lb. pay load consisting of a standard VCO-Multiplex FM Telemetering system plus sensors for altitude, vertical velocity, humidity temperature, airspeed and the static voltmeter output. The output of the SV pitch sensor and a vertical velocity meter are shown in this Figure as the top and bottom trace respectively in both of the records which were recorded at an altitude near 3,000 feet. The top half of the Figure shows a comparison between the best level flight, while under command of the human pilot standing on the ground using visual feedback, and that when the servo loop was closed and the pilot's hands were removed from the control stick. As seen here, the vertical velocity fluctuated through a range of

about 600 ft./minute under human pilot control and this is decreased to about 100 ft./minute when the autopilot was turned on.

The lower half of Figure 1 shows how the stabilisation system operated when the aircraft was balanced so as to possess a divergent phugoid instability. When the stabiliser was turned off, the aircraft entered a series of severe stalls and vertical dives that would have continued indefinitely unless the pilot or autopilot provided some elevator command. Throughout this section of the TM trace, the pilot did not touch the elevator control stick and, as seen, recovery of level flight occurred almost immediately when the stabiliser was turned on. The effectiveness of the stabiliser in both neutral and 'down trimmed' elevator condition is shown.

Measurements with full scale aircraft

One of the photographs shows an installation that has been flown on a Cessna Skymaster in connection with thermal detection experiments using the static voltage sensor. The rig consists of a differential static voltmeter using electrodes mounted on a 10 foot long by 1 inch diameter fibre-glass tube that was attached to the bottom of an instrument pod located at about $\frac{2}{3}$ of the span of the right wing. A conventional attitude gyro was mounted in the cabin near the centre of gravity of the Cessna. Figure 8 shows a recording of data of the two instruments during a small portion of a flight in which the aircraft was pitched up and down by pilot elevator commands while at 3,000 and 10,000 feet altitudes. The top line of each graph is the output (altitude) of the conventional gyro and the bottom trace is that obtained from the static voltmeter. A close similarity of the output on the two instruments at 3,000 feet is evi-

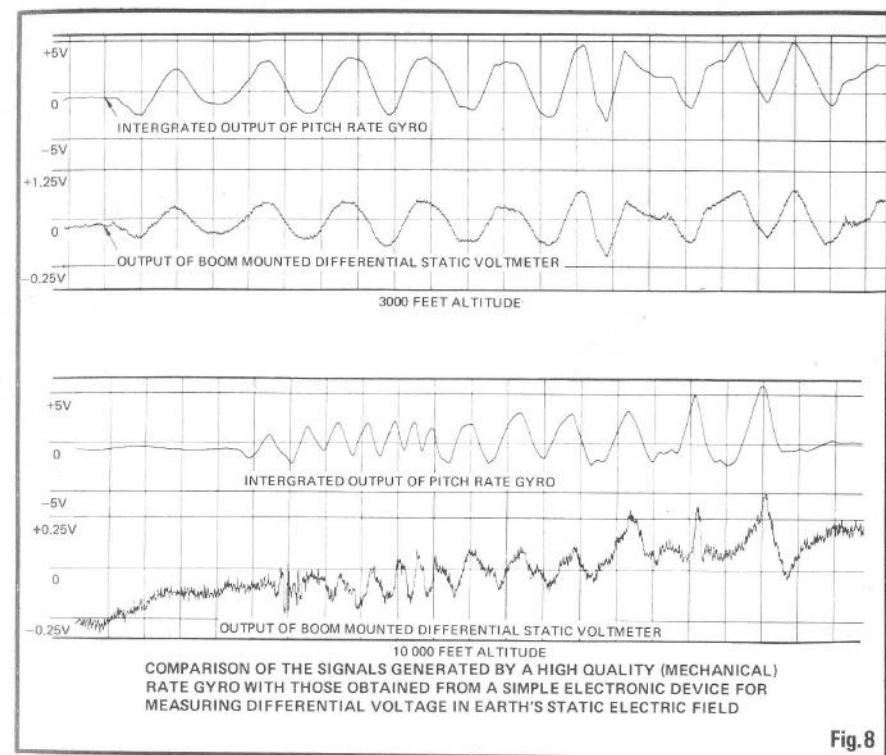


Fig.8

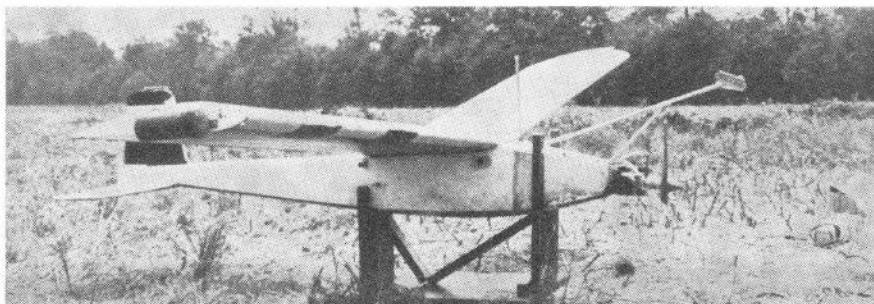
dent. This shows why this simple system works as an autopilot in radio-controlled airplanes. At that particular altitude, it probably would also have worked as an autopilot for the Cessna.

The bottom half of Figure 8 shows a similar experiment at 10,000 feet on the same day. The signal strength from the static voltmeter we found to be greatly reduced as expected from some theories. A multiplication factor of five in voltage was used in producing the bottom line during data reproduction. The long-term upward drift of the SV is believed to be due to a temperature drift within the electronics. A correlation between the conventional gyro and the SV is apparent at 10,000 feet but it is definitely poorer than that obtained at 3,000 feet. So don't barge off and try to set a world

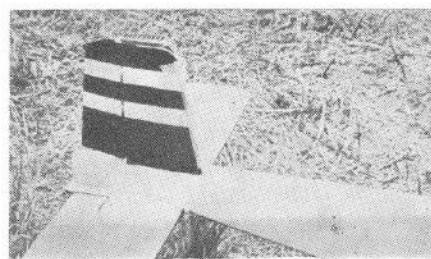
altitude record with this device. Better you should try for endurance at low altitude because the device will let you catch 40 winks of sleep now and then. Watch out Winfred Kaiser! I'm out to take that 12 hour record of yours back again!

Summary of Observations and Conclusions

Approximately 200 flights of electrostatically stabilised radio-controlled airplanes have been made in the states of Maryland, Virginia, Pennsylvania and Ohio. None of these flights extended beyond about 3,500 feet altitude. No serious anomalies or erratic behaviour have been noted. Flights have generally been made in fair weather which included winds to 25 m.p.h. and strong thermal activity



Above: Hill's 'Catbird II' test aircraft once used for altitude record attempts. Note sensors on nose probe and in cylinder at wing tip.



Successful horizontal stabilisation has been observed in light drizzles and on days with 100 per cent cloud cover at less than 1,000 ft. base. Also a few stabilised flights have been made within about a two-mile radius of visible lightning. We have observed the Delta aircraft to occasionally go into roll oscillation on hot smoggy days but this has never been seen on crisp, clear or cloudy, overcast days. Also on hot smoggy days a full hard-over command results in a slightly shallower turn than on cloudy days. Both of these effects are related to pollution and how it affects the voltage in the air. The voltage signals get stronger in polluted air. (Finally, we've found a place where pollution does some good!). 'Hands off' take-offs and landings have been done, as has night flying.

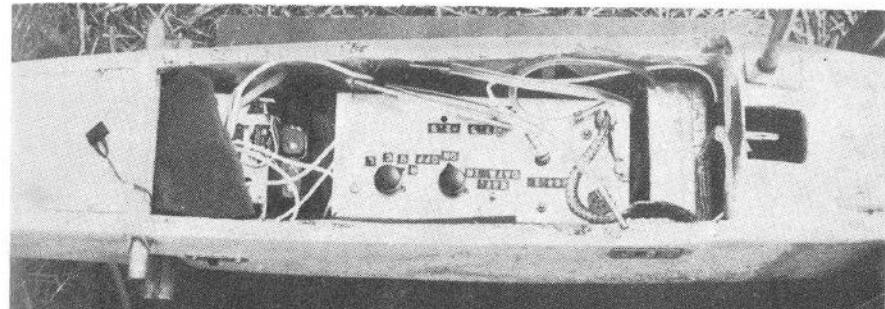
Some models have shown tendencies for a transient pitch up or pitch down originating in the static voltmeter system when engine power is increased or decreased. These pitch effects are

Below: Close-up of radio-active nose and tail sensors. Relation of one to the other establishes pitch angle of aircraft, while wing tip sensors do similar job in roll.

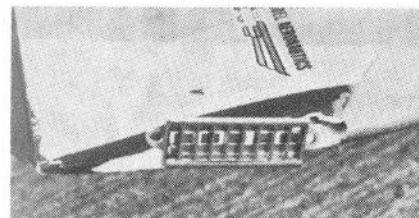


related to velocity effects at electrodes, separation of charges in the structure and/or to generation of charged particles by the engine. These problems can be eliminated by (a) grounding the engine to the electronic ground of the stabiliser (b) placing metal tapes along the longitudinal and lateral axes on the bottom of the airplane and grounding this tape to the electronics (c) facing the radioactive source, into the wind so that the ions blow back onto the metal and (d), put a catching screen behind the sensor.

If the airplane continuously oscillates in roll or pitch, decrease the values of the gain resistors on the op-amps (i.e. the 68 1K's on the triangle circuit!), the Potentiometers in the vicinity of the Zener diode network are used to adjust the neutral trim. Before your first flight, disconnect the coax cables from the voltmeter circuitry and adjust these pots so that there is no deflection of the surfaces when you turn on the



Below: Close-up of wing sensor, a commercially available unit in U.S.A. Above: 6 channel tele-metring radio used for Clear Air Studies, installed in model.

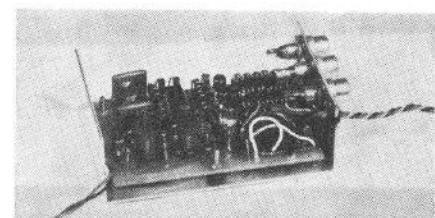


activating channel switch. (We use the retract gear channel of the Kraft for this). Take off with the switch turned off and get some altitude before you turn on the switch. If the model goes into a climb, dive or bank, you must trim the one or the other potentiometer for appropriate corrections.

You should not try to fly during a thunderstorm. Apart from the fact that the autopilot might turn you inverted or crash your model, it is a bit unsafe to be standing in an open field with a transmitter antenna poking into the sky during a thunderstorm. We have flown in drizzles, in high gusty winds, at night and over water and it works fine. If your flying field is in a valley between tall mountains, there is no guarantee that the device will make your airplane fly level. It could, instead, cause the model to try to fly parallel to the face of the mountain. Flying close to smokestacks with electrostatic precipitators on them could also cause a crash.

The principles employed in electro-

Below: the autopilot, which measures 1 x 23 in. and weighs approximately 3 ozs. Some of the components used are fairly expensive.



static stabilisation provide only for roll and pitch control. There are no means to derive heading information from this particular device. However, over short distances such as in speed runs or pylon races, it could provide smooth and straight flight without noticeable deviation from its initial course. I can envisage the possibility of flying a pylon course without having a pilot on the control stick. If I'm successful at this, I might finally get into pylon racing! Among other things, my ears can't stand the noise out there in the middle of the course. But if I could fly it from $\frac{1}{4}$ mile away with a pre-recorded tape of a good race, that's something else! But this is a long way off'. Simple employment of the device to assist pylon pilots in flying a smooth course is not without complications. Special modifications to the circuitry will probably be needed for these high speed and highly manoeuvrable craft.

This device will have limited usefulness in aerobatic models. It could help on those straight and level entries and

exits and it could help on straight inverted flight. It also makes smooth automatic landings in spite of gusts. But when you turn the stabiliser on, you cannot roll, loop or spin. The craft simply does a mild sweeping turn or a shallow climb or dive under full stick command. So flying an aerobatic pattern would be a process of turning the stabiliser on and off many times during a competition flight. There are other ways to use this device for aerobatics whereby it would be possible to programme the whole stunt flight with no assistance from a human pilot. This would take extensive circuit modifications that are not included here. I see little point in trying to develop such a modification as it would sure take the fun out of aerobatic competition.

We have not done it yet, but it is pretty obvious that the system ought to make helicopter flying a lot easier. There are some technical problems too. The reader should be advised that this is a very new device and that there are unknowns left to be examined. This article is presented for those who are experimentally inclined and curious about new things. I will try to provide answers to questions or explanations for problems that you might encounter, but please be patient with me if you don't get an instant reply. This thing has me pretty busy. I hope that those modellers who do try it will report back any unusual experiments or improvements that they achieve as this kind of information will be a valuable help to progress with this new device. We'd like very much to gain experience in various climates, locations and altitudes with a variety of airplanes so please do let us know how you're doing. You can write to the author in care of *Flying Models* or at The Johns Hopkins University, Applied Physics Laboratory 8261 Georgia Avenue, Silver Spring, Maryland 20910.

Acknowledgements

Very special thanks are due to John Rowland for originating an experiment that became a key ingredient in the combination of circumstances under which this invention was conceived. I am also very grateful for subsequent technical assistance that he provided during development of practical devices.

Valuable technical advice was provided by a number of people both in and outside of APL. Among these are William H. Avery, Raymond H. Cramer, Walter A. Good, Tom M. Albert, M. Stone and Alfred J. Zmuda of APL, John S. Foster Jr., Department of Defence Research and Engineering, and William A. Hoppel of Naval Research Laboratory, their assistance is appreciated, as is the help of Raymond C. Cole, Jacqueline A. Hentgen, Barbara S. Keck, Christian A. Keller, Stephen R. King, Frederick W. Klein, Joseph L. Lew and Roger O. Weiss who worked hard and accomplished many unusual tasks during this project.

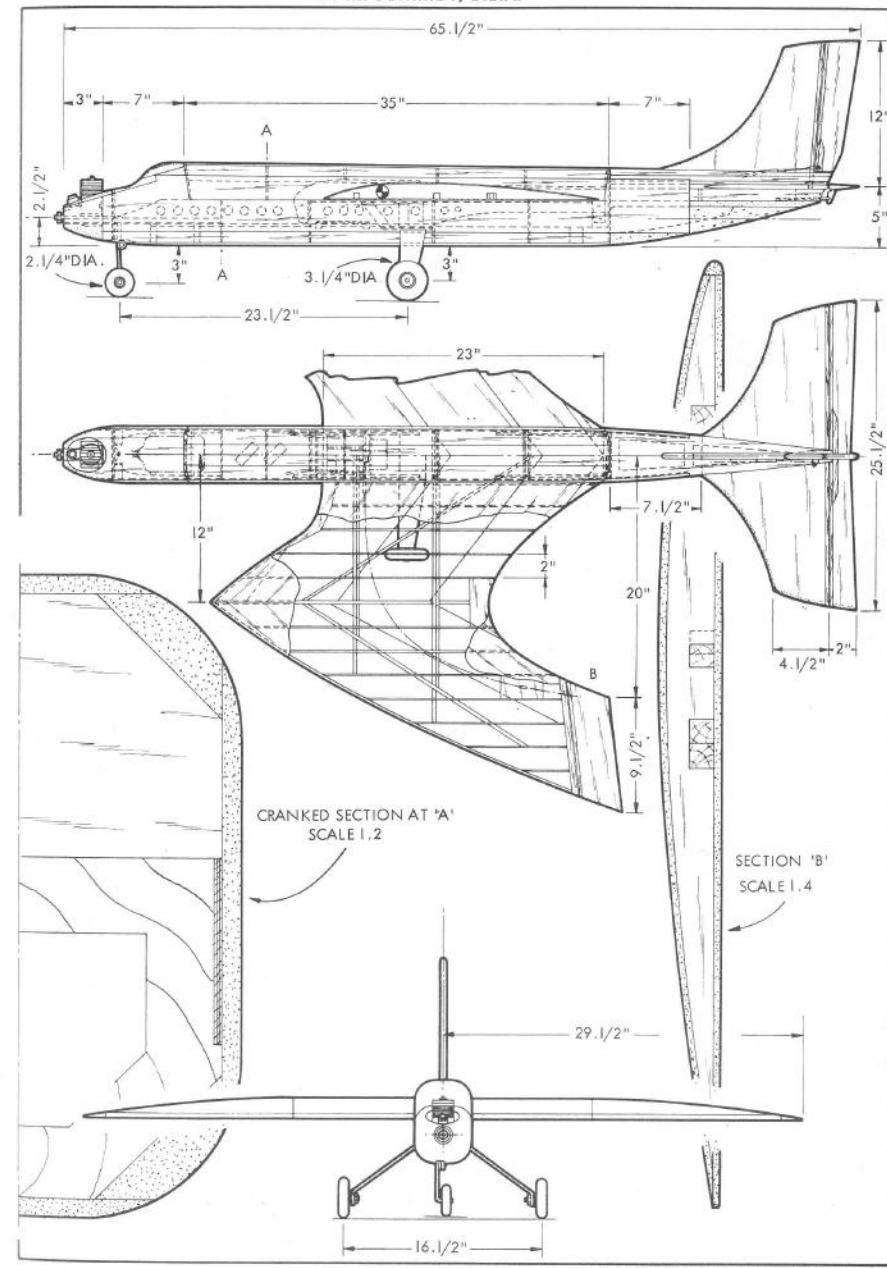
I am also indebted to John Worth and Frank Ehling of the headquarters staff at the Academy of Model Aero-nautics for providing technical information regarding unusual aeromodeling techniques as well as to Don Lowe and Dennis Ingerbretson, WPAFB, for supplying information gained during flights in a different location from ours.

The ongoing support of Col. Herbert M. Federhen and Col. William Kirlin of the Advanced Research Projects Agency is gratefully acknowledged.

RC X4

Radical, bat winged,
eyecatching RIC machine
BY M. SCHMIDT, U.S.A.

Scale 1:16



ALL ABOUT HI-STARTS

By Ray Smith

A HI-START is as important to a glider glider as an engine is to a power flyer. A power modeller looks for an engine which will give him a good power and last longer than others. An active power modeller will spend £20 to £30 for an engine which lasts two seasons. For a modest sum, a glider pilot can purchase a good hi-start which will last several active seasons.

The rubber used in the hi-starts I have is made to meet a rigid Government specification. It consists of a mixture of natural virgin rubber and polyisoprene rubber compound to give maximum stored energy and long life. It has an elongation of 200 per cent of the slack length. In order to meet the Government specifications it must withstand 35,000 cycles. The cord must also withstand an aging test of 160 degrees (F) for seven days with a 20 per cent decrease in strength. This aging test is equivalent to about 5 years of use under normal conditions.

Cheaper power cord can be made from surgical tubing and it does an adequate job for smaller gliders. Since rubber is exposed to the sun it will not last nearly as long as the exerciser cord, but it can be very satisfactory over a short period of time.

In Table 1 are some general guidelines for gliders being flown today using a 600 feet tow line.

The above chart is based on having a breeze of about 7 m.p.h. With less breeze, use an additional 40 feet of power cord. With more breeze, don't pull it back so far. The average glider being flown today has a span of about 9 feet and a wing loading of 10 ounces

per square foot and will require a 160 feet power cord.

Proper storage of the Hi-start will lengthen the life of the power cord. Since the power material is a good grade of rubber, heat will cause deterioration. Store the power cord in a place where the temperature stays at room temperature. Don't store it close to a heat source such as furnace or hot water heater. Sooner or later, your Hi-start will get wet, most likely because of dew on the grass or a sudden rain storm. When wet, store the power cord where the air can freely move around all parts until it is dry. If stored in a box while wet, the cotton jacket will mildew and rot. It won't hurt the power cord to get wet provided it is properly dried when you get it home.

One question I hear being asked is: *'How far do you pull the Hi-start back before launching?'* Assuming you have gone through the necessary training period, you will want all the power you can get out of your power cord. The power cord I use has a stretch of 200 per cent. The useful stretch of the cord itself is limited by its modulus of elasticity. Stretch the rubber up to that point and it will spring back to almost its original slack length. Stretch it past that point and a permanent elongation will occur. Stretch it still further and at some point the strands will break.

The jacket on a good power cord will serve as an indication to you. The jacket is woven around the rubber strands so that the jacket can get longer as the diameter gets smaller—

up to a point. After that point, the jacket fibres themselves stretch.

On a well designed power cord, the material elongation process stops before you reach the critical stretch of the rubber strands. You can feel the tension suddenly increase when you reach that point. Since the jacket fibres themselves are somewhat elastic, there is a natural desire to keep pulling until it won't stretch further. This is a mistake and seriously effects the life of the power cord.

Within some limits the height you get on a Hi-start launch is a function of total stored energy. After a year or so of use, a noticeable decrease in total power will develop depending on how much it is used, care in storage, how much it has been over-stretched and other factors. It isn't necessary to buy a new power cord to bring the power back up. Just snap on a short additional section, and the power will be the same or greater than when new. As a power cord ages, the total potential stored energy is less. Add on a length of new power cord, and you can bring the total stored energy back up.

When fully stretched, the Hi-start has about 20 pounds pull, the same force as a 20 pound bow. If the tow ring is let go, it is a pretty potent missile and could really hurt someone. Don't let people stand along the tow while it is stretched out. Even if the ring doesn't hit them, the tow line can cause a nasty cut or burn.

When pulling the tow line back, don't put the cord over your shoulder. If the line should pull loose at the ring, the line could cause a bad cut or at least a burn. I saw it happen and it burned through the man's shirt and caused a burn on his back.

A misconception exists on the use of Hi-starts for small or lightweight gliders. First, we have said in the past that for small gliders, you can use a shorter power cord. If you stop to think it through however, a short power cord develops the same initial force when fully stretched as does a long one. This initial force gives too much power for the small glider. It results in either an extremely fast launch or breaks the wings.

The initial force at launch is proportional to the amount of stretch in the power cord. For smaller or lightly constructed gliders, don't pull the cord back so far.

The total stored energy in a power cord is also proportional to the amount of stretch. So if you decide you want 70 per cent of the maximum initial force, the total energy will be about 70 per cent of the maximum that can be stored at full stretch. You can get the same stored energy with less initial force by adding additional power cord.

In summary, for a small glider use 120 to 160 feet of power cord and don't pull it back so far.

TABLE I

Glider	Span	Wt. lb.	Wing Loading Oz./Sq. Ft.	Rubber Length
Kurwi 33	8' 4"	4 lb.	12	160 feet
Kurwi 68	12'	5 lb.	10	160 feet
Osprey 84	7'	2 $\frac{1}{4}$ lb.	9	120 feet
Osprey 98	8'	3 lb.	12	160 feet
Osprey 120	10'	6 lb.	13	200 feet
Osprey 168	14'	10 $\frac{1}{2}$ lb.	12	(2 strand) 200 feet
Orrus	8' 4"	3 $\frac{1}{2}$ lb.	9.4	160 feet
Ormulus	8' 4"	3 lb.	9	160 feet
KA 6E	12'	11 lb.	24	(2 strand) 200 feet

SLOPE SOARER AEROBATICS

By Ken Binks

SLOPE soaring started way back when free flight was the most common means of flying. Models were launched off from the top, half way down or near the bottom of the hill, depending on the wind strength. These models were trimmed to fly in a straight line and weathercock into wind, so that a maximum flight duration could be achieved actually soaring on the ridge, rather than just disappearing off down wind, which I'm afraid eventually happened. Another method that was adopted was magnet steering which enables a model to stay directly off the hill by using a magnet to maintain its heading, this operating an auto rudder.

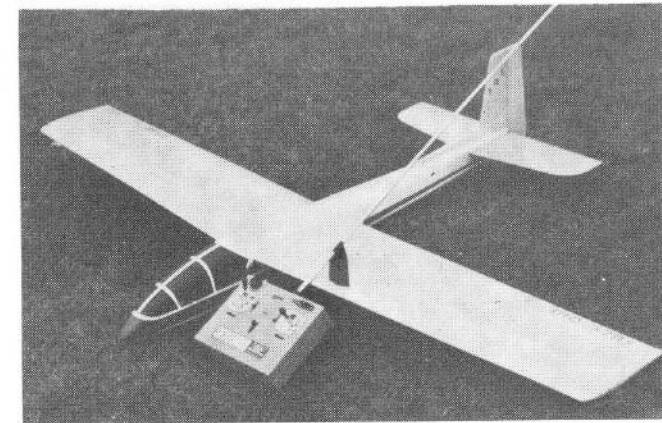
Although still in use today, this was soon superseded by single channel radio control on rudder only. This then enabled the pilot to fly a model up and down the ridge and stay in the hill lift. Duration was dependent on the number of turns one could get on the rubber loop which powered the actuator, this being the popular means of controlling a rudder at that time. Then, with the more sophisticated reed multi-channel outfits coming along, slope soarer models began to appear with rudder and elevator controls. These were the very basic primary functions and continued for some while. But now with the more reliable (compara-

tively) proportional systems and greater control offered, any model becomes a practical proposition.

Models at this time were still semi-scale in appearance, high aspect ratio, very much after the lines of their big brothers the full size gliders. But gradually with the introduction of more sophisticated radio control the pilots demanded greater manoeuvrability from their models. So there had to be a change in the general outlook and design thinking of the modellers, and the aspect ratio of the wings was then cut down from anything above 10, down to 8 and 7, or even 6.

In the first instance, these lower aspect ratio wings were tried without ailerons and some fair aerobatics were possible with the model just fitted with rudder and elevator. When I say elevator, all moving tail would be more to the point as, due to models being fitted with semi-symmetrical wings, it was found at that time that negative manoeuvres were quite hard and all moving tails came into fashion, to get over this problem. But compared with today's models, of course, they were pretty pathetic. Although cutting down the aspect ratio of these models made them capable of barrel rolls, even axial rolls were possible. This was at a time when contest schedules demanded both

Right: author's current aerobatic slope soarer design, the Suzy Que Mk. 5, soon to be kitted by Model Flight Accessories. Design uses rudder, elevator and aileron controls.



barrel rolls and axial rolls, perhaps two in sequence. But this is not quite the case now and competitions are asking for 4, 6 and 8 point rolls, so greater control in the rolling plane was necessary and hence the use of ailerons.

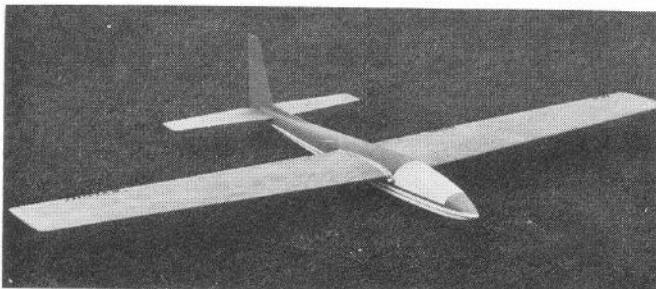
In the elevator plane, more and more negative manoeuvres were being called for and this necessitates going to very thin fully symmetrical wings which then make the model capable in the negative plane but, of course, reduce their performances in the normal positive lifting plane. So these models were then poorer in low lift conditions.

These models were working at quite

high wing loadings and this also was a contributory factor, in their poor marginal performance. Development then tended towards attempts at Variable Section wings, about a third of the chord of the wing could be drooped or raised, depending on whether the model was flying inverted or upright. This was to improve the lift co-efficient of the wing while looking for lift and doing positive and negative manoeuvres. But when rolling manoeuvres were required the wing could be returned to the symmetrical state thus giving better axial rolls etc. These models were developed for about 3 years and for the work and time

Right: Sleek 'Phase Four' design by top glider aerobatic pilot Chris Foss has slim fuselage for minimum drag.





Attractive 'Xyloid' aerobatic slope soarer by M. Baker is similar in shape to author's 'Suzy Que' machine.

that was involved weren't all that successful.

The off-shoot of these experiments were models with flaps akin to old control line and indeed present control line practice, in that the wings had flaps which work in opposition to the elevators and provide greater lift in turning and lifting manoeuvres. This now is about as far, I think, aerobatic slope soarers can go. They can do any manoeuvre. So for the purpose of this article I will be assuming that the flyer has a model of this type i.e. fully aerobatic and correctly set up. As slope soaring gliders have no means of propulsion whatsoever, except the wind, and gravity, and are using these entirely to stay up and to provide necessary speed to do manoeuvres, I think it's very important to understand how to build up excess speed and also how to use the wind to your advantage. Now this will become apparent in the positioning of manoeuvres, relative to where the judges are standing for competitions. The most important point to understand is how to get excessive speed out of the glider to enable manoeuvres to be done. Now this can vary from gaining the speed before you start the manoeuvre, to use of the lift to enable you to gain some more speed during the manoeuvre to complete it, for example, in consecutive loops or bunts (outside loops).

Before commencing any manoeuvre one cannot just apply the control

deflections and expect the correct result. In reasonable lift conditions the best way to build up speed is to initiate a very shallow dive, not a sharp vertical dive with a sharp pull out, but a shallow dive resulting in a shallow recovery, at which point a good deal of excess speed will be gained which can be used in the manoeuvre. If the sharp dive, sharp pull out technique is used, all the speed gained in the short dive is lost in the sharp recovery due to high drag in the sharp pull out. So begin with a nice shallow dive before starting any of these manoeuvres to gain excessive speed which will carry the model through the manoeuvre. It should be emphasised that except for square and sharp manoeuvres, the smaller the control deflections that can be used, the



greater the speed left for the manoeuvre.

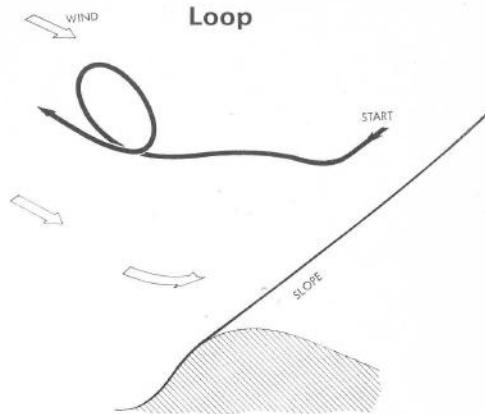
Let's start with the perennial favourite of all non-aeromodellers, the loop.

Loop

This should be performed *into wind* and so that the roundness can be observed necessitates positioning off to one side from where you are standing on the slope. To start a loop, we must first gain speed and this must be done as mentioned before. Then after levelling out call 'loop'. Pull gently into the loop and as the top of the loop is reached, ease off slightly since the elevator tends to become more effective at the top due to the gravity effect on the model. Then, as the model goes past the three-quarter point, gradually pull out and finish up at the same altitude as entry. Exit in straight and level flight calling, 'finish'.

That's all very simple for one loop, but now when it comes to consecutive loops the problem is one of good superimposition and it is a good idea to get a bit more speed initially, then start the first loop as before.

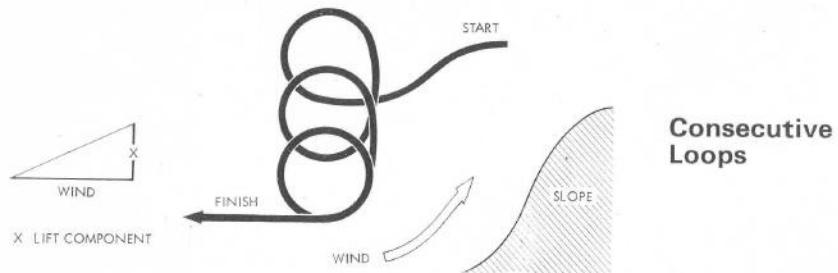
At the three-quarters position when the model is diving back towards the ground before the final pull out, the



model must be allowed to dive just a little bit more than you would normally to gain a little excess speed, which is then used for the second loop. This must then be superimposed on the first loop and again try to gain speed after the three-quarter position when the model is diving down. All this has to be equated against the lift available at the slope. If the lift is very strong it is easy to superimpose the loops because the ground relationship is for the loops to be rising up the slope. So by diving the model at the three-quarter position it is possible to keep up the speed, making possible as many loops as are required. But it is



'Long Nose' aerobatic soarer by Ricky Shaw is another slender fuselage, minimum drag machine.



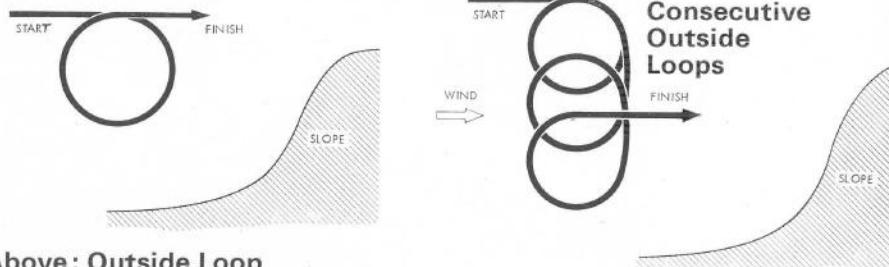
Consecutive Loops

dependent on the lift strength to achieve as much speed as possible during the manoeuvre. Again when you have finished the set number of loops, exit level with the initial entry level. This manoeuvre is very hard to perfect.

Outside Loops

Sometimes called a 'bunt', this manoeuvre has to be performed *down wind* in the same position as the inside loop. That is, off to one side so that the manoeuvre can be observed from the side. It is still necessary to gain speed in a shallow dive, but level off coming towards the slope about 50-70 yards out. Then, push the nose down and under. It is necessary to gain ground upwind in the inverted position before climbing back up for the second half of the outside loop.

So, from a shallow dive, push the nose down, flatten off at the bottom slightly and then push in more elevator to climb back up the other side finishing up at the same altitude as entry.



Above: Outside Loop

cock assisting the stall turn which you are trying to perform.

For a left hand stall turn, start with a little bit of extra speed and fly from left to right pulling up into a vertical climb smoothly. Maintain the straight vertical climb, then as the model slows down, push the rudder fully over to the left. This, coupled with the weathercocking effect of the wind as the model stalls will accomplish the turn. The model retraces its path to a level pull out at the same altitude as entry.

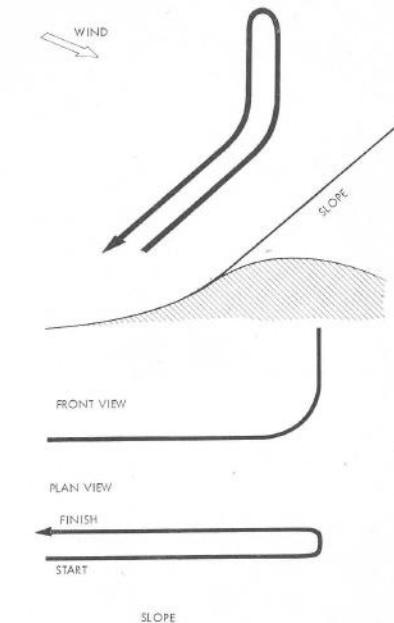
It follows that for stall turns to the right the model must be going from the right to the left, so that when it is in its vertical climb and stalling, the wind is going from the right hand to the left hand wing tip and will assist you in doing stall turns to the right. It also follows from this that the Chadel or wing over is possible, but this is just a matter of applying the rudder before the model has completely slowed down so that a wing over i.e., a turn in excess of two wing spans is accomplished.

Rolls

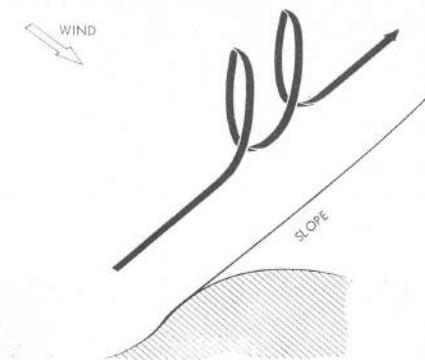
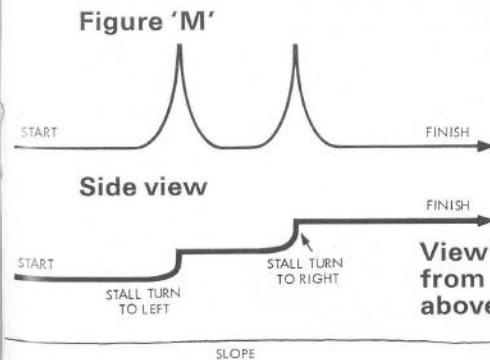
These are performed *crosswind* so that the start, finish and altitude can be observed.

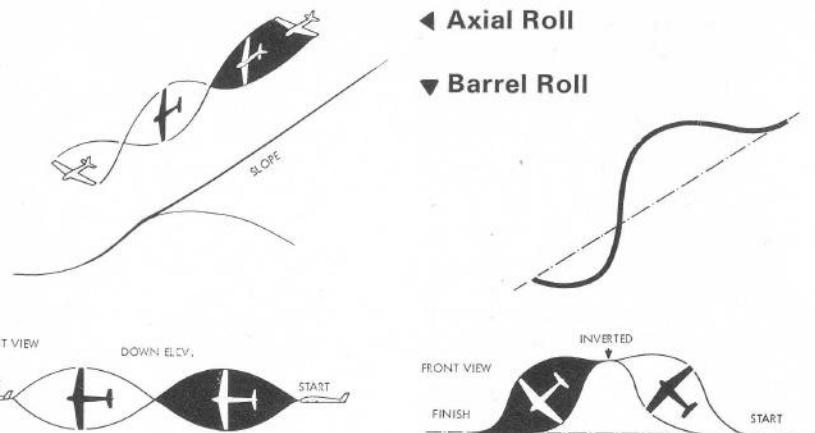
First we will take one axial roll. This should be performed after a shallow dive and levelling off. Full

Stall Turn



ailerons are applied and as the model reaches the inverted position, slight down elevator is required to maintain the altitude at which the manoeuvre was started. Then as the model is passing through the inverted position, elevator is released to return the model back to the upright position without losing altitude. This should be started and finished with the wings level.





Barrel Roll

To do a barrel roll, the model must be maintained in positive G throughout the manoeuvre. That is to say that no down elevator is applied but the manoeuvre is started with a slight climb. The ailerons are applied and slight up elevator is applied simultaneously. This will keep the model positive throughout the manoeuvre and a corkscrew type path is scribed. Such is a barrel roll.

Two point Roll

It then follows that a two point roll is possible by stopping an axial roll at the inverted position.

So, after a shallow dive, half roll, introduce slight down elevator and hold the inverted position after releasing the ailerons. After perhaps, a two second interval, re-apply the ailerons and roll back to the upright position. This should be spaced out so that the first half roll and the inverted and the second half roll are roughly the same length in time.

Four Point Roll

It also follows that we could stop the manoeuvre at every 90° , but when we do this, there is nothing maintaining the model in a level altitude. So we

◀ Axial Roll

▼ Barrel Roll



must use top rudder. For a right hand roll, from a shallow dive, level off, apply the ailerons and release so the model scribes exactly 90° . At this point left rudder is introduced to maintain altitude. This is then released as ailerons are applied to pass the model through another 90° , at the same time progressively putting in down elevator to maintain altitude in the inverted position. Then apply ailerons to return the model to the three-quarter position and apply right top rudder. Finally release the rudder and apply the ailerons to return back to level flight.

This manoeuvre is initially quite a sweat but once a bit of practice is gained the manoeuvre is completely automatic and instinctive. You just do a 4 point roll and your thumbs are pushing the sticks in all the required directions without even thinking about it.

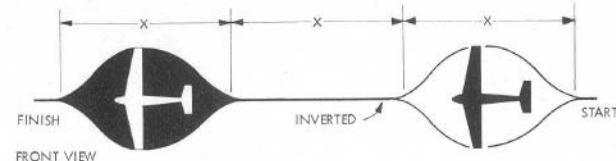
Eight Point Rolls

An Eight Point Roll is possible, stopping every 45° , but in the 45° points top rudder and elevator are both required to maintain altitude and to keep the manoeuvre exactly axial. This is really a matter of practice.

Three Point Roll

The same applies to a Three Point

Two Point Roll



Roll which is stopped every 120° and, providing it's only one roll, not too much top rudder and elevator are required. Careful judgment in stopping every 120° is required.

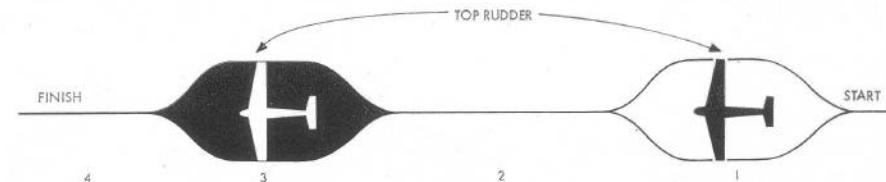
Inverted Straight Flight

Inverted Straight Flight should be performed *crosswind* and should be started from a half roll. This should be done with a little excess speed to make the entry nice and crisp. Then maintaining level altitude, the model is kept inverted for the requisite 5 or 10 seconds, before rolling back to the upright position in the same direction as the entry roll, to complete the manoeuvre.

Inverted Circle

For an inverted circle, we start at the into-wind position. Taking the inverted circle to the left, the model starts the manoeuvre by rolling to the right, with the half roll, not quite 180° but with the model on the angle of bank necessary to take it round the inverted circle. In the case of the left hand inverted circle we roll to the right, because this is the shortest distance to the angle of bank required for the turn. Then, maintain altitude with ailerons and elevator to complete the inverted circle, remembering that more elevator and ailerons will be required

Four Point Roll



on the down wind leg because the model increases its ground speed as it flies toward the slope. As you come round to complete 360° , roll out in the opposite direction to the entry with a half roll to the left, since this is the shortest path back to level flight, and looks much more professional than a $190-200^\circ$ roll the opposite way.

That's some of the more basic manoeuvres, now we should go on to more complicated manoeuvres which string some of these basic manoeuvres together.

Cuban 8

Enter this going *crosswind*. Taking it from the top, start with a fair turn of speed after a shallow dive. Pull up elevator and go over the first part and then hold a 45° drop after three-quarters of a loop. At a pre-determined intersection point, half roll, continue down and start your second three-quarter loop with the bottom of the loop level with your entry. Pull over the loop, back down at 45° , half roll at the intersection point again and finally recover to finish the manoeuvre. As I said this is easiest performed going crosswind.

Horizontal Eight

This also is easiest to perform going *crosswind*. So starting off with a fair



Inverted Circle

ANGLE OF BANK
ROLL TO RIGHT
LESS THAN 180°
FINISH ROLL TO LEFT

SLOPE

turn of speed, level off, pull up into a three-quarter loop. Then, when in the vertical position squeeze in down elevator to do a complete bunt, to pull out level with entry. This is basically just a case of stringing a loop and a bunt together, making sure to maintain even size between the two and level exit and entry points.

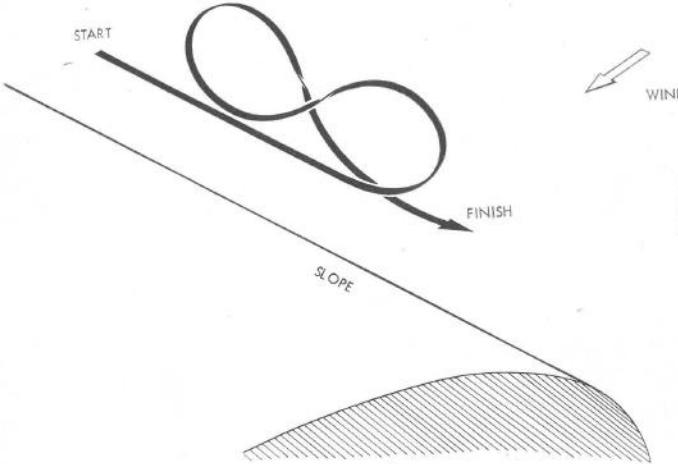
Vertical Eight

This is just a matter of rotating a

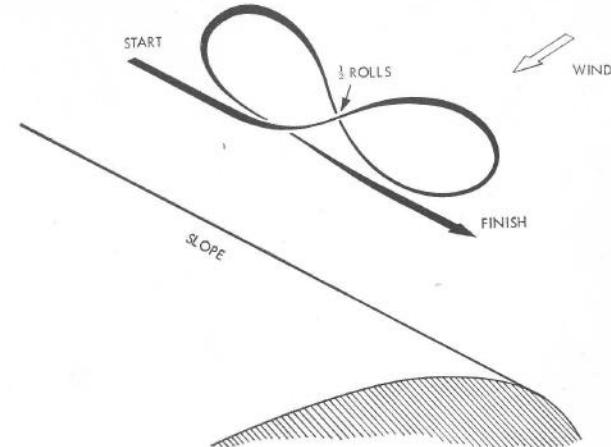
Horizontal Eight through 90°, performing a loop and then a bunt as before.

Double Immelman

This is probably best performed *crosswind*, pulling into a half loop, and half roll, then diving into the half bunt with a final half roll to finish. This manoeuvre requires a fair turn of speed because large aileron deflections are required at the top of the half loop.



Horizontal Eight



Cuban Eight

Single Immelman's, can be either positive or negative. The negative version can be performed going towards the slope with a half bunt and a half roll out, or a positive one can be performed going into wind then pulling up into a half loop and a half roll out of the manoeuvre.

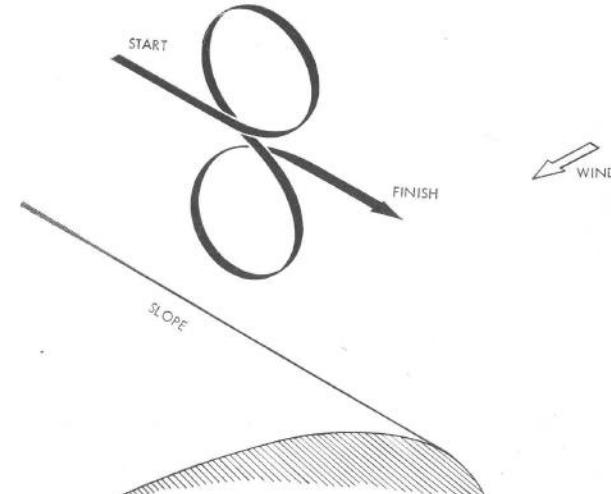
Variations

Taking a few of the more complicated F.A.I. manoeuvres, we will look at the *Figure M* first. This is basically

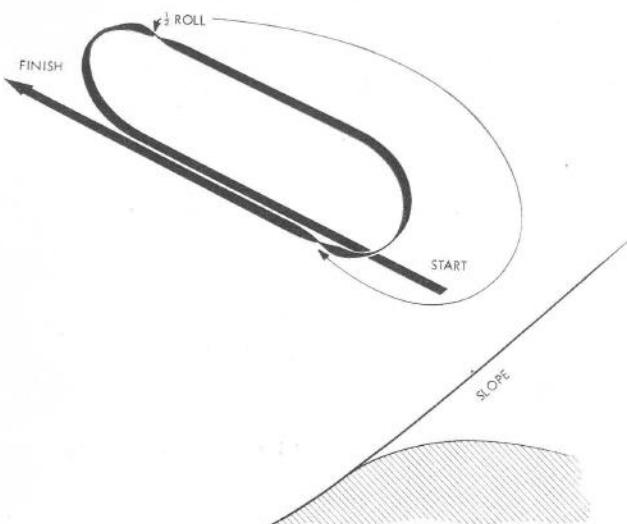
just two stall turns linked together with a half bunt. It should be performed cross wing with a stall turn to the left, followed by a negative pull out back up into the vertical position and a stall turn to the right. Follow this with a level pull out, level with the entry at the bottom of the half bunt.

Top Hat

A great deal of speed is required and this manoeuvre must be performed into wind, because after the first half



Vertical Eight



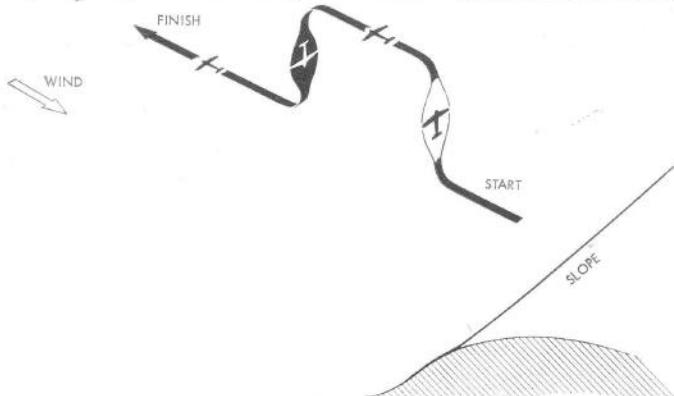
Double
Immelman

roll, up elevator is required to level the model off into the inverted position and you must have enough flying speed here to prevent a stall. So if we can do the manoeuvre into wind and increase the air speed over the wings by the positioning of this manoeuvre, it is to our advantage. So start with a good deal of speed, dive, level out then make a nice gentle change through 90° into the climbing vertical attitude. A quick half roll is then followed by a change of 90° with the up elevator, to fly inverted across the top. Pull up elev. to bring the model

into a diving altitude, then half roll to finally exit upright, straight and level.

The only problem with slope soarers is that the speed through this manoeuvre doesn't remain constant. Its not quite so pretty as is possible with a powered aircraft but it is a manoeuvre which is fully within the capability of the modern slope soarer.

That just about covers the more conventional manoeuvres. There are many manoeuvres which can be done in free style type competitions, such as Negative Cuban 8's, flick manoeuvres



Top
Hat

incorporated with loops perhaps, and these are really up to the flair of the individual pilot.

Most flick manoeuvres rely on very fast control movements which are also very effective. If you want a positive flick manoeuvre, its a matter of putting rudder and ailerons the same way with up elevator. If you want a negative flick roll you use opposite ailerons and rudder with down elevator. This has to be done very sharply, say, at the top of a loop and necessitates equally quick recovery to complete the second part of a loop. Such stunts are impressive if achieved with accuracy. I feel that actually describing many more manoeuvres is not really practical because if a pilot has the ability to do those already described, he will also have the ability to evaluate these things for himself and add and subtract them from any schedules he might perform.

Contest Technique

Because of the way slope soaring contests in Great Britain are run (i.e. many individual clubs run national competitions all of a different nature and to different rules), one must use the rules and regulations applicable to each competition to your advantage.

This may sound obvious but it's amazing how many people don't do manoeuvres in the required order to gain maximum points. So it is very important when entering competitions to read the rules thoroughly and note exactly the designated order of the manoeuvres to gain the maximum points. This, coupled with little subtleties such as relaunching etc. is not really cheating, but accepted competition tactics.

For competitions, positioning of manoeuvres might have to be modified to suit the judges. That is to say if you persist in flying your manoeuvres right in the sun you can't expect the judge to mark something he can't see. So take

into account quite a few things before actually positioning your manoeuvres, such as the wind direction, position of the sun, and your own ability to do the manoeuvres. You will find most top fliers do all their manoeuvres CROSS WIND for the judge even though it is harder.

One final point concerning nomination of manoeuvres and informing the judge exactly when you are going to start and finish the manoeuvre. You don't want your initial speed gaining dive to be judged as part of the manoeuvre, so a typical nomination would be 'Next manoeuvre—loops; starting now . . . finish now.'

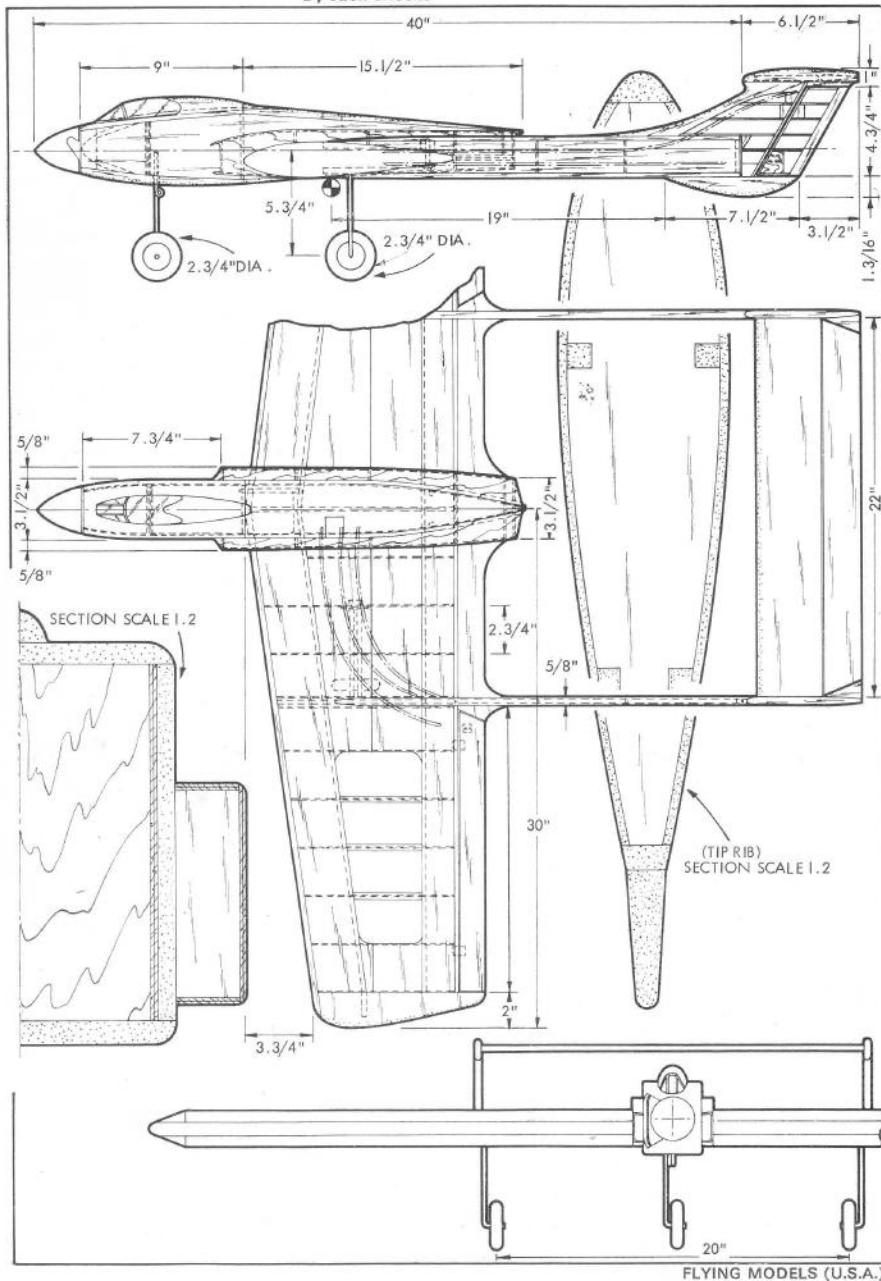
In free style, it's usually the one or two rather complicated manoeuvres which are impressive and influence the overall marking. This, combined with a consistent and crisp flight pattern coupled finally with a good landing right at your feet, does create an overall impression which will add to the marks awarded. It all boils down to showmanship, and inverted launches and like things are all methods of gaining points and doing something which is different from your competitors. Such is the only problem with free style, to think up all the new ideas!

With the lack of enthusiasm for the formation of the slope soaring side of the B.A.R.C.S. (British Association of R/C Soarers), it would appear that the average slope soaring modeller doesn't want to be regimented into any sort of order. They prefer competitions with all the different set ups, giving a little touch of individuality rather than a set schedule for aerobatics which will become boring and repetitive, as is the F.A.I. schedule in power R/C. I believe that slope soaring appeals far more to the average type flyer who flies for fun and doesn't want to get too seriously involved.

Sea Vixen

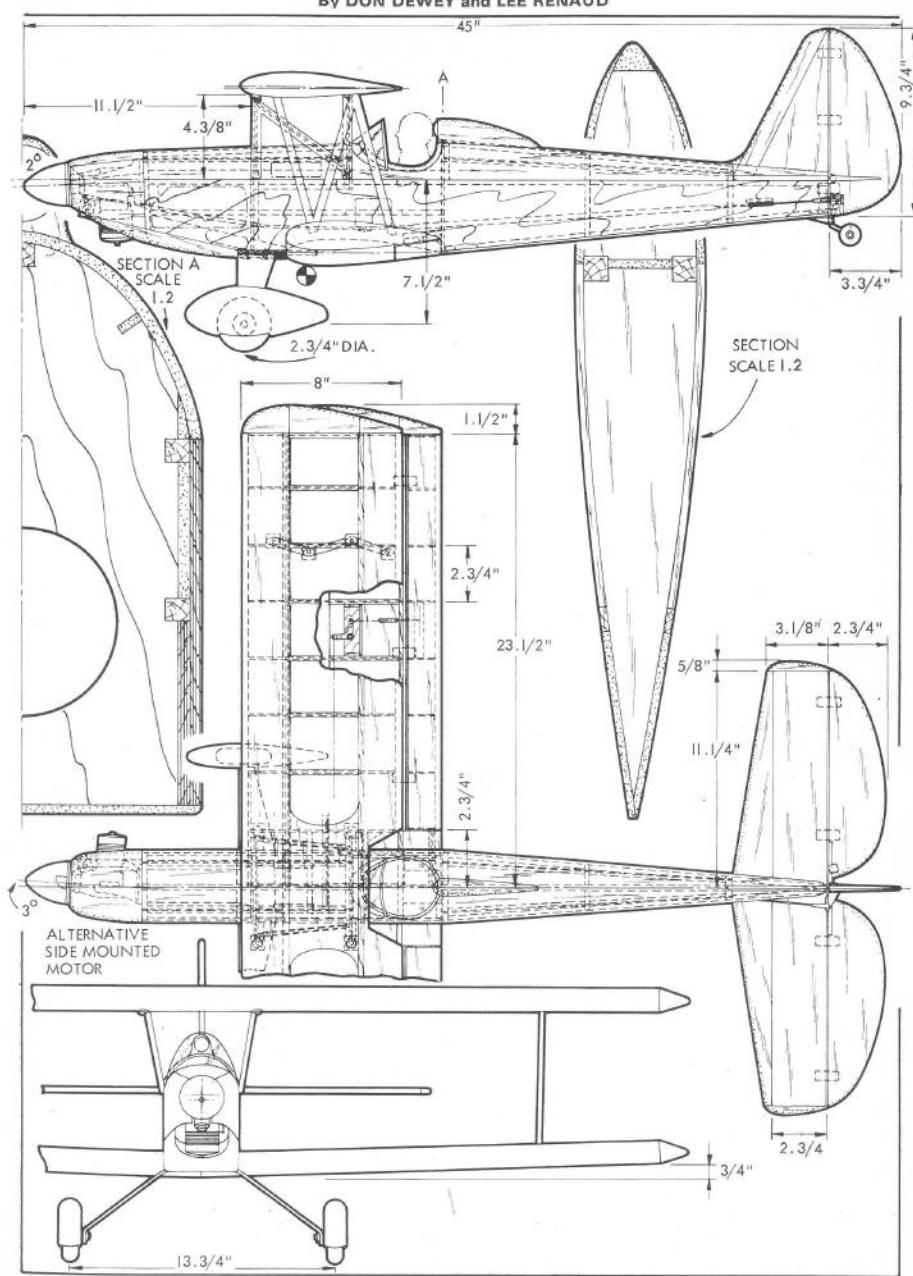
Semi-scale twin boom
aerobatic R/C model
By Jack Sheeks

Scale 1:11

**Acro-Star**

Purpose-designed,
fully aerobatic biplane
By DON DEWEY and LEE RENAUD

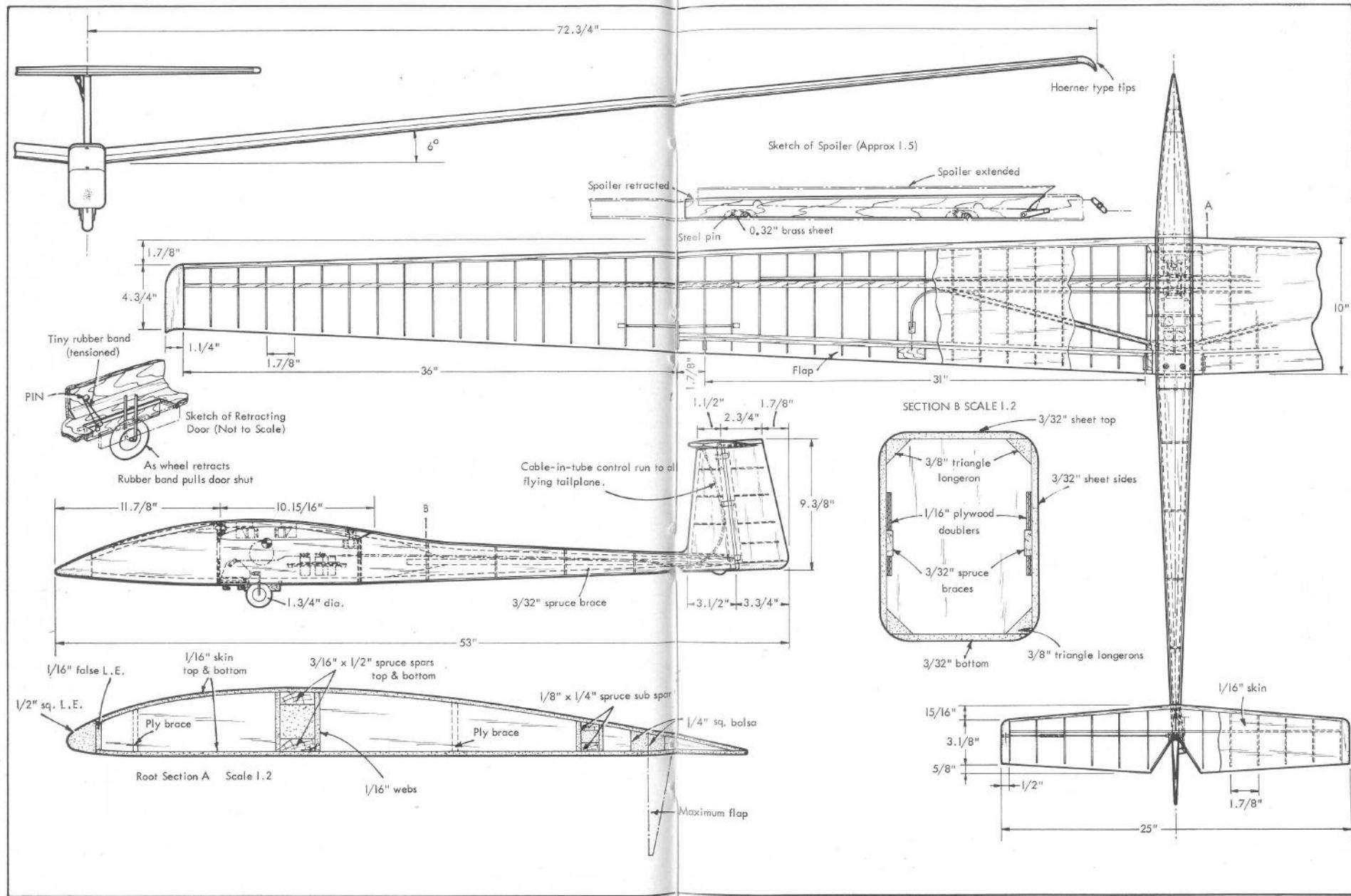
Scale 1:10



Quasoar

High performance thermal soaring glider
featuring flaps, spoilers and retracting
undercarriage

BY NIEL LIPTAK
Scale 1:10



EXPERIMENTS IN R/C STOL (Short Take-Off and Landing)

By Peter Russell

'STOL', the initial letters of 'Short Take-Off and Landing', is a bit of aeronautical jargon which, with the associated terms 'VTOL' (Vertical take-off and landing) and 'QTOL' or 'QSTOL'—the Q is for quiet—is appearing more and more in technical conversations and writing, and for good reason. As land values continue to increase and ecological considerations become more important, aeroplanes, other than intercontinental airliners, that are capable of operating from relatively small areas will become increasingly important. Just how important can be gauged from the fact that when De Havilland Canada were setting up the design criteria for their new DHC-7 inter-city airliner, an ability to operate from a 2,000 ft. strip was considered one of the first essentials, based on the premise that in years to come, land and building costs were likely to make this the maximum economical, and perhaps the maximum *possible* size for the large town or small city airport.

What is likely to be a problem for full-size money-making operations is bound to be even worse for the enthusiast who flies for pleasure and indeed, it already *is* a problem for many of us. So what can be done about it? Fortunately, a lot can be done about it, and some of us are already making R/C models that can fly at below 20 m.p.h. and operate from areas many times smaller than those normally used for R/C models.

'STOL' is a term that has come into prominence fairly recently, but Stol aeroplanes have been around for a long, long time. Gerhard Fiesler might be considered to have started the trend in the mid-thirties with his Fiesler 'Storch', but as far as operating from small fields is concerned, it would be pretty fair to say that Tom Sopwith was building Stols (the 'Tabloid', for instance) before World War I. In World War II, there were two specially built Stols, the 'Lysander' on our side and the 'Henschel 126' of 'theirs', but neither was very successful. The main snag with both of them was that a higher-than-average pilot skill was needed to realise the Stol potential, and flown by the average squadron pilot they were just cumbersome low-performance aeroplanes. Later in the war the 'Army Co-operation' and communications functions were taken over by much less sophisticated but more versatile 'light' aeroplanes like the 'Auster' and the 'Storch', not to mention the various U.S. light planes that were pressed into this role.

So much for the historical side, it is really in the last ten or fifteen years that most progress has been made. Not so much from the point of view of reducing landing and take-off runs to a minimum in absolute terms—helicopters have taken over in this sector—but more in order to allow relatively big, load carrying aeroplanes to operate from small 'farmer Giles'-type fields.

Model aeroplanes, R/C variety, have developed along lines uncannily similar to those of their full-size equivalents, and the modern high-powered aerobatic model can be considered the counterpart of the jet fighter. Its handling qualities are remarkably similar in many respects, and in particular, it is at its best when operating from smooth tarmac runways. A skilled pilot can land the average aerobatic model *across* the usual R.A.F. type runway, which means about 150 feet of concrete, particularly with the help of a bit of wind. But this is not the same as saying that the model could be operated from a 150 foot square—far from it. On the average approach, the model will be down to ten feet or less three hundred feet back from the touch-down point, and at the 1973 British Nationals, where competitors were landing across the runway, with the 'spot' in the middle, no model was able to stop in the 75 feet of runway left after the touchdown point was reached, and this includes models fitted with brakes. Since these models were flown by the country's most skilful pilots, it follows that the average pilot would want a big margin over the figures mentioned to allow for errors of judgement, so putting it in round terms it is safe to say that for average pilots a field or strip at least two hundred yards long is needed for everyday operation. In practice, the average club pilot finds operation from a football pitch even with fairly clear approaches, distinctly taxing.

The writer's interest in reducing the space needed for R/C operation came about during a period of immobility during 1971. With a lawn 140×35 feet, it seemed it would be an interesting and worthwhile project to see if it would be possible to design and build a model that could be operated, on a regular basis, from this area.

There were, it seemed, two possible approaches. One was to build a more or less standard aerobatic model, fitted with sophisticated high lift devices. Plain flaps would help, but would give nowhere near the extra lift necessary for this kind of operation, so that some kind of complicated area-increasing flap, possibly with leading edge 'droop' as well, might be necessary. Since there are other houses quite nearby, the project had to be 'Qstol', not merely 'Stol', and the use of the usual '60' size engine might be a problem in this direction. The other approach was to build a light, simple aeroplane, with a simple high lift wing, using relatively low power (to keep the noise down) but with the light weight still giving a high power: weight ratio. From previous experience with sport type models it seemed that three pounds would be the absolute maximum permissible weight for the project to be successful with the preferred '19' size engine. No sweat so far, but now further questions arise. Is it economical sense to build a plain *flying machine* capable of operating out of the garden, full stop? Answer 'no'. To be worthwhile, the model would have to be reasonably interesting and lively, at least semi-aerobatic, and with plenty of 'stretch-potential' for those odd jobs like banner towing, glider towing, flight photography and such like. As for the structure, 'modern' methods involving all sheet/block construction leave a lot to be desired from the point of view of strength : weight ratio, whilst the 'quick build' propensities of these structures are largely illusory due to the amount of carving, sanding and finishing involved. So after all this cogitation, it is not surprising that the 'Stol Mark One' when it finally appeared in the May 1973 *Radio Control Models and Electronics* (q.v.) had a distinctly nostalgic look about it.

Stol Handling

Flying this model was very much like any other 'sport' model except that, because of its light weight, it was a good deal more 'lively', whilst the average club pilot would find the controls a good deal more sensitive than usual. This is because, at the unusually low air speeds at which it was hoped to operate, 'ordinary' controls would be near useless—literally. After a good deal of practice on a marked area on the normal airfield, the model was successfully flown out of the lawn already mentioned, looped and rolled, flown inverted, and landed back on the said lawn. This, on a flat calm summer evening in 1972. Whilst the 140×35 feet 'strip' might not seem particularly small to an experienced pilot—in ideal conditions quite a number of existing designs would probably be able to use it, but it is a 'one-way-in, one-way-out' strip, i.e. all take-offs are on a heading of 310 degrees and all landings are on the reciprocal 130, so that if there is any wind at all you are either cross-wind, or either the take-off or landing is *down-wind*. As it happens, mostly it is the landings that are at least partly down wind, the worst possible situation for the most critical part of the flight. However, in calm conditions, the 'Stol I' flew on a number of occasions from the lawn, without accident—as far as is known, the first model to fly 'back garden' operations, repeatedly at any rate.

The technique of flying in these conditions is quite a bit different to 'airfield' operation. Apart from the fact that when you are running down a 35 feet wide strip with trees lining the sides, you can't allow much of a 'swing' to develop, take-off presents no problems, and the 'Stol' has frequently got off in less than half the available length, even with a slight tail-wind. The landing is the bit which



Writer's 'Stol Mk. 1' demonstrates vivid short take off and steep climb out, using optimum 20 degrees take-off flap setting 48 in. span, three pounds weight, O.S. 19 engine heavily muffled.

needs knowledge of Stol handling techniques, practice and concentration as well as a suitable model. Basically the technique is to set up the model for a slightly longer than average final approach, reducing speed quite early. Here an engine with really good throttle response and a reliable idle is absolutely essential, as is the ability to fly your model accurately quite near to the stall. To fly at this sort of speed, quite a lot of power is needed beginners will be surprised to hear, whilst powerful elevators are necessary to hold the model in the required pitch attitude. The only practical way, as well as the correct way, to fly the final approach leg, is to control the rate of descent with the throttle and the speed with the elevators. The practice of some pilots of using the elevator as



Stol Mk. 1 again, this time on finals with full 85 degree flap setting. Although in level attitude, model is in fact descending steeply, very near to the stall with engine at about one-third power.

the up-and-down control on the final approach, leads to big variations in speed, and holding a steady airspeed, just above the stall, is the vital factor in Stol landings.

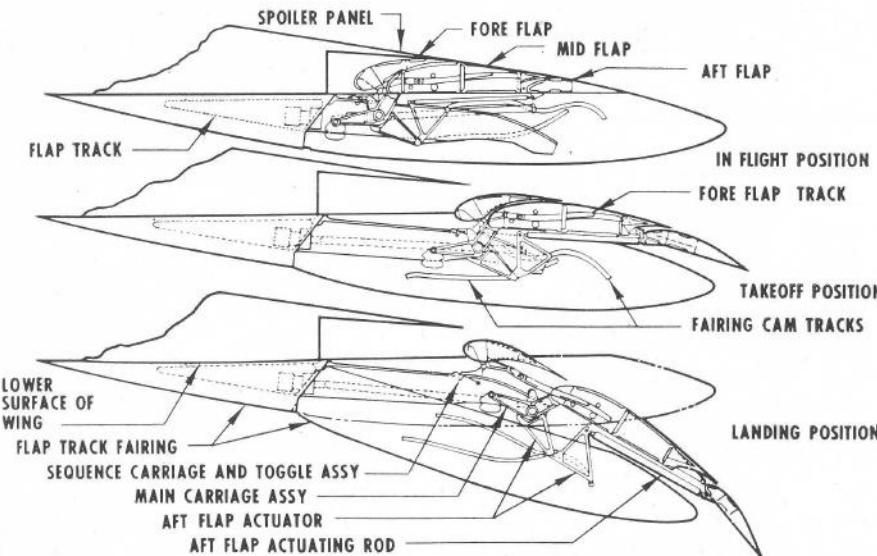
With the 'Stol Mk. I', providing that all the above had been flown accurately, the final flare was performed in the usual way, and, after a short 'float' the model would land and stop well within the allowable 140 feet. Come in just 5 knots too fast, however, and the float phase alone would use up all the 140 feet. Any down-wind component makes matters worse as well. The reason for float being such a problem is that, although not what would be described, aerodynamically, as a 'clean' model, at the sort of speeds involved the drag is very low indeed. To this must be added the fact that

with the high thrust / weight ratio of the lightweight model, even at idle the engine is still producing enough thrust to prolong the 'float' phase of the landing quite significantly.

So the 'Phase One' Stol was a limited success in that it had done all that it had been intended to do, but 'limited' in the sense that the whole operation of 'back garden' landings was very critical and limited to ideal conditions—i.e. flat calm.

'Phase Two'

The idea of the original experiment was to see if the lightweight, high-power (relatively speaking) and high-lift 'simple' approach would deliver the goods. When it became obvious that the answer was a very qualified 'yes', the next step seemed to be to investigate the properties of the various lift and drag producing appendages and decide which would be most appropriate. Basically, the main need was for more *drag* to deal with the troublesome 'float', but any increase in *lift* would also be useful in that it would enable the approach to be even slower. Flaps of some sort would have to be fitted, but what sort of flaps? Reference to full size publications showed a bewildering number of configurations, as well as considerable divergence of opinion on the properties of the various types. The diagrams and graphs represent an average of several different sources, and from these I deduced that the split flap would give me the best compromise in terms of lift: drag and complication: effectiveness. Slotted flaps are now increasingly popular in full size, but it seems this is mainly because, with the widespread use of flap for take-off, reasonably low drag is important. As stated above, with the model take-off is no problem anyway, and high drag is needed to reduce float. 'Fowler' flaps are very good, but again produce

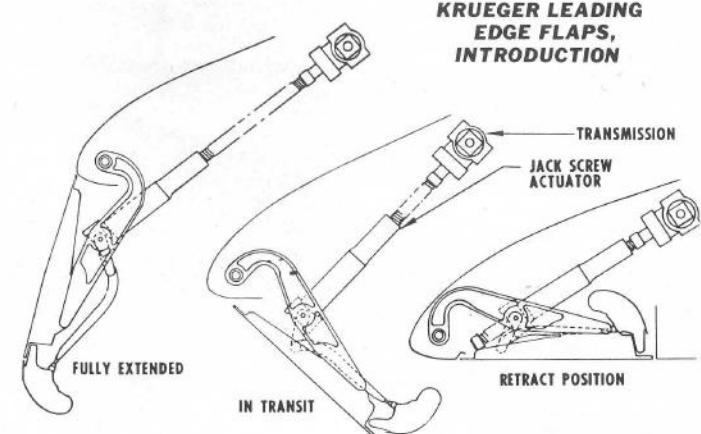


TRAILING EDGE FLAPS, TRIPLE SLOTTED, INTRODUCTION

more lift than drag, and introduce linkage problems which would involve a significant weight penalty. The jet airliner deal with the triple slotted flap and leading edge droop is really appropriate only to that type of flying machine, which, without them, would be completely impossible. As a matter of interest the increase of lift with this kind of set-up is variously described as 'double' or 'triple'. Even the elaborate Boeing 707 wing, which has a slat on the leading edge of the slotted flap plus the 'Kruger' leading edge flaps, represents a mere intermediate stage in the aerodynamic chicanery necessary to allow these things to fly. When the requirement for the short haul Boeing 727 included operation from 5,000 ft. runways—about half the normal jet runway—Boeing took the 707 wing apart and eventually came up with the fantastic triple slotted flap with Kruger flap inboard and leading edge flap-cum-slat on the outboard section all of which added up to successfully achieving the 'field

performance' required. Even this is not the ultimate. Many aeroplanes now have 'blown' flaps in which high pressure air is bled-off from the compressor stages of the engine and blown over the top of the flap—all of which is very interesting by way of an aside, but scarcely applicable to model aeroplanes. In fact, after a careful review of the many factors involved, a simple split flap was fitted to the 'Stol Mk. 1'. This involved little complication and the additional servo was the only weight penalty. Earlier experience with slots had indicated that these were not particularly effective and hardly likely to 'pull their weight', so these were not used.

Flight tests with the flaps showed them to be very effective, rather more so than full size experiences with similar flaps would have indicated. The expected nose-up trim change was very marked but could be handled by rigging the elevators so that full nose-up trim was needed for normal (flaps-up flight), making the full trim range



KRUEGER LEADING EDGE FLAPS, INTRODUCTION

available when the flaps were put down. A co-pilot would be useful to apply full flap and full nose-down trim at the same time, and so avoid the somewhat twitchy situations when the pilot tries to do this and fly the aeroplane at the same time. As for the landings, a new snag now became apparent. With full flap, the model could now be flown slower than before, due to the significant increase in lift, and at the speeds that were now possible, yaw and roll stability deteriorated to a serious extent. Fortunately, the control response was still entirely adequate, even at these speeds, but after about a dozen landings, simple leading edge slats were fitted and this completely cured the low-speed stability problem. As a further indication of their effectiveness, The Stol Mk. 1, which would previously spun quite readily and was in fact once spun accidentally, became, with the slats, quite spin-proof.

In this configuration, regular 'garden flying' became quite practical, even in choppy winds of up to 12 knots. Downwind landings with the wind up to 10 knots are not difficult, and even 'flame-out' landings have several times been made without too much strain though it must be admitted that luck,

as well as good management is needed for these emergencies!

The flaps give a number of useful advantages. First, the extra lift, which is considerable, enables a lower airspeed 'over the fence', or, put another way, it isn't necessary to fly it quite so near to the ragged edge of the stall in order to be sure of stopping in the available landing run. Second the increase in drag is useful in several ways. It steepens the approach path, so that apart from the obvious advantage for coming in over obstructions, there is the slightly less obvious but equally definite fact that the steeper the approach path, the easier it is to judge the touch-down point. It is also possible to fly the approach with more power on. This increases the effect of the elevators and rudder, as well as increasing the flow of air over the flaps. Equally important is the reliability factor in that a fast idling engine is less likely to stop than a slow idling engine. This is very important because if the engine stops during one of these drag-it-in-on-the-point-of-the-stall type approaches, the aeroplane stops flying immediately, which is unfortunate if it happens to be twenty feet up at the time. Finally the extra drag cuts out the float entirely if



the approach speed has been held accurately, and dramatically reduces it even if you come in too fast. The best technique with these very slow engine-on approaches seems to be to leave the power on until the touch down, so that it can help with the flare.

Though not originally considered as a take off aid, the flaps can help here too, particularly when the slats are fitted. Anything up to about half-flap can be used (more than that gives an uncontrollable pitch-up when full power is used) and the take-off run, already short, becomes even shorter, whilst the angle of climb (see picture) becomes almost unbelievable for a fairly big model with a mere 19 engine.

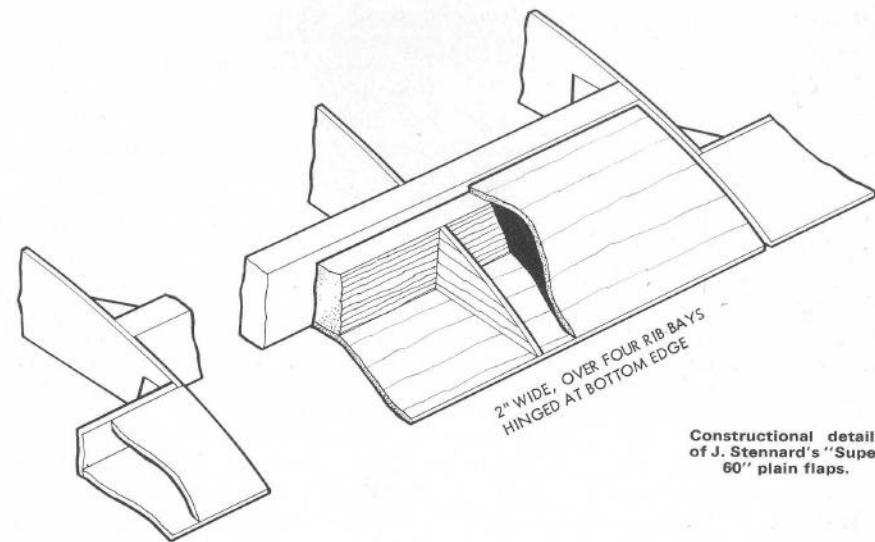
Other STOL experiments

Mention of these experiments and the ultimate publishing of the plans of the 'Stol 1' in the *Radio Control Models and Electronics* magazine led to a good deal of correspondence. Many wanted to discuss the purely theoretical aspects of the exercise, but about a score were actually flying models intended for confined space operation. The first of these was John Bridge, famous later for his R/C scooter, whose Merco 35 powered model had slats and plain flaps. John got all the usual handling qualities,

R. M. Pilgrim built this Super 60-based Stol which has D.F.S. type airbrakes as well as large area, 85 degree split flaps. Very 'Stol' but some control problems at ultra-low airspeeds. Note bracing wire, highly recommended by author.

including the strong pitch up when the flaps went down and the running out of control at the 'ridiculous' airspeeds of which the model was capable. He concluded his letter: 'As for flying in and out of the back garden this is not on at the moment as I need more yaw/roll response at low speed and more power to give a better climbing angle—it's a nice thought, though!'

John Addison sent some diagrams of some very simple split flaps that he had applied to one of his models and said: 'As you will see they could hardly be simpler, but then comes learning to fly with them, which is another matter altogether'. Mr. Addison found the nose-up pitch a nuisance but taught himself to fly approaches holding the stick forward—an uncomfortable situation, model or full size—most pilots, for some reason or other, are quite happy holding a bit of back pressure in an aeroplane that is trimmed nose-heavy, but feels uneasy when the situation is reversed. Mr. Addison's conclusion is 'Using a fairly small flying field with lots of obstructions, I find that flaps give me slower, safer take-offs and landings, and slower, steeper approaches so



Constructional details of J. Stennard's 'Super 60' plain flaps.

that trees and other obstacles can be avoided'.

Jo Ivens reported that he had been using flaps on models with high wing loadings, some of them biplanes and said that he genuinely found it easier to land, using them. He makes the unusual comment, 'My experience firmly contradicts your comment that all models get a nose-up change of trim when the flaps are lowered. All

mine go nose down, which is what you should expect, begging your pardon!' Of all the correspondents who had actually flown flapped models—as reported, about twenty—only Mr. Ivens reported a nose-down-pitch when the flaps were lowered. An earlier impression that most full-size aeroplanes go nose-down when the flaps are lowered turned out to be far from true. In fact many full size aeroplanes



J. Stennard's 'Super' Super 60 incorporates all 'Straight & Level' modifications, but also has large area 60 degree plain flaps. Uses O.S. 40 engine.

share the nose-up pitch of the models, including some very famous ones, Wellington, Lancaster and Canberra, for instance.

Looking into this trim change business a bit deeper, it becomes obvious that the whole subject is much more complicated and unpredictable than might be thought. Basically, any wing, considered alone, will pitch nose down when flaps are put down. But when you nail the wing onto the rest of the aeroplane, the downwash from the wing—which is always present when the wing is lifting and more pronounced with flap application—then hits the tail and whether the complete aeroplane then pitches up or down depends on the relative magnitude of the two forces. The layout of the aeroplane itself seems to be the main factor. The type of flap doesn't seem to make much difference. For instance, the three wartime heavy bombers, Lancaster, Halifax and Stirling were basically the same layout, four-engine, mid wing, moderate aspect ratio, and about the same size and weight. They had very different kinds of flaps, however. The Lancaster had split flaps, the Halifax plain flaps, and the Stirling had the more sophisticated Short-invented 'Gouge' flaps which were similar to Fowler flaps, in that the flap moved backwards and downwards, increasing the wing area, but the flaps themselves were of a curved section which gave a better overall wing section when the flaps were down. In spite of this wide variation in flap design, all three aeroplanes pitched nose-up when the flaps were lowered.

By comparison, the Boeing 747, which, with the 727 has one of the most complicated wing-flap configurations in civil aviation (*triple* slotted flaps with Kruger leading edge flaps and upper surface 'lift dumper/speed brakes') has, as would be expected,

a much more involved trim-change sequence. From 'full-up' to about 10 degrees down, there is a slight nose-down pitch. From 10 to 20 degrees there is a pitch up, and from there to maximum down, which needs to be only 30 degrees because the flaps are so big and because lift is the main consideration, there is a marked pitch nose down. Reference to the drawings of the 747 flap configuration will indicate just how much development on the plain flap idea there has been.

It seems that the reason for the model trim change being usually nose-up is something to do with the low pressure area behind the flap reducing the tendency of the upper-wing airflow to early separation which increases the lift and the downwash, which, hitting the tail plane, is the cause of the nose-up pitch. Apparently in full-size scales the tendency to separation is much less, so the effect is not so noticeable.

Mr. J. Stennard, who is an English teacher in Rinteln, W. Germany, wrote, 'After reading the various references to the "Super 60" and recommended modifications thereto, I decided to build one, with the mods. suggested, but also with (plain) flaps, maximum deflection about 50 degrees. As you can see they are quite big. The model is very nice to fly, with the O.S. 40, as yours originally was, but the flaps make it just that bit more fun. With the engine throttled back the nose rises when the flaps are lowered but the trimmer takes care of that. The angle of descent is steeper than normal and (with practice!) you can land in a matter of yards. With the motor cut back and the flaps down, low, slow flying is really great. For take-off, with a bit of flap she is off the ground and climbing like a lift after a very short run. Truly the "60" is a great fun model and with the flaps even more so'.



Martin Reed's second thoughts on Stol design. This one has a 54" span, Merco 35, full span L.E. slats, slotted flaps and ailerons.

R. M. Pilgrim of Teeside is another who used the 'Super 60' as a basis for his Stol experiments, but his mods go a bit further. The span is increased to 76 inches and ailerons are used. In addition to split flaps, he also has D.F.S. type (glider) airbrakes sprouting from the top and bottom surfaces of the wing. He says, 'For short take-off about 15 degrees of flap in an 8 m.p.h. wind gives lift-off in about ten feet with another 20 feet or so to clear a 15 feet obstacle.'

'When the brakes are selected (non-proportional) the nose pitches down and full trim plus about $\frac{1}{4}$ back stick is needed to balance this, which, with the high rate of descent, means that I have not enough elevator left to round-out which leads to heavy landings. With the flaps (only) down, the situation is reversed in that full down trim plus $\frac{1}{4}$ stick forward is needed. Round out is possible by releasing the forward pressure on the stick, but it is tricky and the landings tend to be a bit bouncy. With flap and brakes, the technique is to select brakes first, then apply sufficient flap to bring the model back to trim. The throttle is

then used to control the rate of descent. This is normally high, but controllable. Roll response deteriorates at low speeds and demands concentration.' He says he now needs extra control power to deal with the ultra low-speed condition, and might try slats too.

Martin Reed of Loughborough's original Stol was based on the M.A.P. 'Electra' 54 inches span, and fitted with full span slats and slotted flaps, both of novel section. Mr. Reed gets round the trim change problem by having the flaps fixed in the down position, though this, of course, limits performance in other directions. He says, 'At normal speeds the model behaves like any trainer but when throttled back with up elevator it will remain airborne at about 15 m.p.h. In a breeze it can be hovered overhead indefinitely or lowered vertically onto the runway. In the latter manoeuvre it just starts to move forward as it gets into the ground effect air and the actual landing run in these conditions is about four feet! For take-off, in still air it needs about thirty feet to get flying speed and then it can be "leapt" into the air up to about fifteen feet altitude.'

Mr. Reed's development of this model had zero dihedral in the wing

and ailerons were fitted, the longitudinal dihedral was reduced to zero, to improve handling and a stronger undercarriage was fitted with the 'Sokol' type 'reversed tricycle' layout. He says this one will leap almost vertically the first twelve to fifteen feet after take-off 'when a quick burst of full down is applied, before it starts to come backwards, and away we go!'

of full down is applied, before it starts to come backwards, and away we go! The reduced longitudinal dihedral means that I don't have to constantly use down elevator when the speed goes up. I was a bit worried that the ailerons, which are also slotted and drooped, might be ineffective in the low-speed/high angle of attack situation, but they have proved to be effective at all speeds. No doubt this effectiveness at low speed is due to the factor you mentioned—that slotted flaps, and, presumably, slotted ailerons as well, give lower drag for a given amount of lift. I enclose a drawing of the wing section used. Manoeuvrability in normal fast flight is good and the model can be rolled and flown inverted. In short the model will fly as slowly as the earlier one but now has the ability to perform quite a few aerobatic manoeuvres. The speeds and other figures quoted are approximate as no timed runs have yet been made.'

Mr. Reed's last remark about timed runs raises the interesting point about estimating speeds. This is extremely difficult and can be widely off the mark. The writer's 'Stol Mk. 1' seems to be the only one of the models mentioned that has been so timed and the following figures, based on averages of many runs on several separate occasions, can be taken as accurate to 1 m.p.h.

	m.p.h.
Maximum speed	50
Minimum speed, flaps up	21
Minimum speed, flaps down	12

This speed range of 4:1 will handsomely beat almost any model flying

This speed range of 4:1 will handsomely beat almost any model flying, view to compiling a later review on Stol developments.

(approx.) m.p.h.

Maximum speed 128

Minimum (stall) speed, flaps up 44

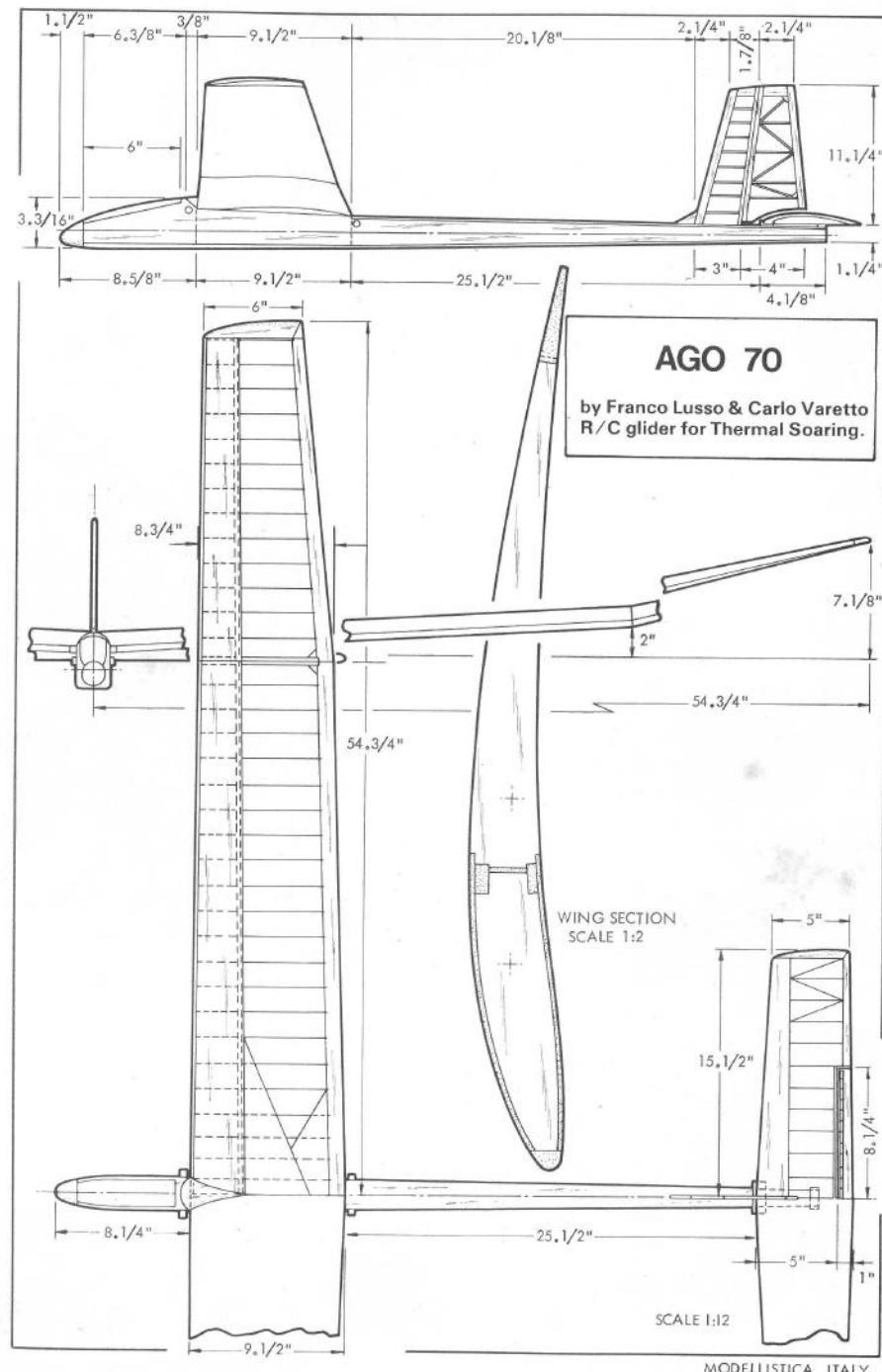
Minimum (stall) speed, flaps down 37

Relative to the Stol Mk. 1, the much smaller difference between flaps up and flaps down speed will be noted.

What next?

From experience already gained, it would be entirely feasible to build a fully aerobatic model, of a similar layout to those currently in use, but with a lightweight structure, and using split flaps and built in 'letter box' slots, that could be operated from the same sort of area that the Stol Mk. 1 is now using. Its only foreseeable handicap, relative to the 'normal' aerobatic model would be in its lower wing loading which would make its gust sensitivity higher, sacrificing that highly desirable 'smoothness' which is the outstanding feature of the current generation of eight and nine pound contest aerobatic types.

Of the pure Stol types, no doubt even the 12 m.p.h. of the Stol Mk. I could be improved upon, but at this speed the model becomes very sensitive to even mild gusts, and it is doubtful if there is any point in trying to fly slower still. What *might* be profitable would be to use more sophisticated flappery to allow models with a substantially higher wing loading than the Stol, to be able to land at the same speeds, and the writer would be glad to hear from modellers experimenting in this direction with a view to compiling a later review on Stol developments.



A MODELLER'S APPROACH TO RPVs (Remote Piloted Vehicles)

(Reprinted from American Aircraft Modeller)

By Ken Willard

EARLY in 1971, I received a call from old-time modeller Bob Palmer who works for the Lockheed California Co. They were undertaking a programme of research on remote piloted vehicles (RPVs) as potential combat vehicles. For government oriented research, it was a very low budget effort.

As a feasibility demonstration, they proposed to undertake an approximate 1/10th scale flight demonstration programme to learn more about the capabilities, and limitations, of RPVs. How precisely can the flight path be controlled? Is air-to-air combat feasible, or would the initial target acquisition be too difficult? There were many other questions too.

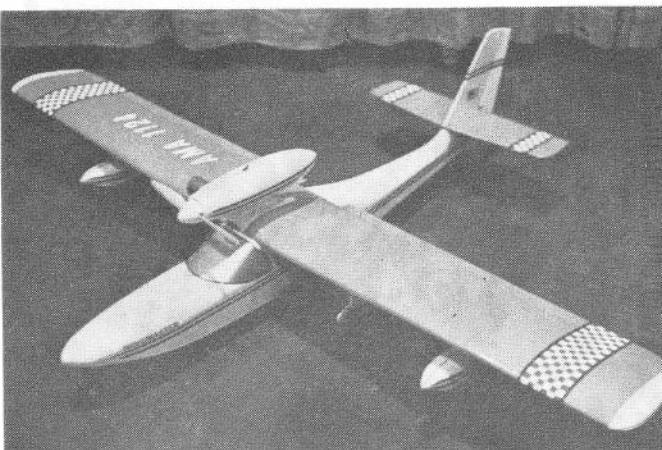
Lockheed had earlier developed a small, lightweight experimental TV

camera, and a matching lightweight transmitter. So, the idea emerged—mount the camera and transmitter in a radio-controlled airplane, and try to fly the airplane entirely by reference to the picture transmitted by the camera to a monitor screen receiver installed inside a mobile van.

Bob called me, on behalf of the Programme Manager, to inquire about the availability of a couple of *Wavemasters*, the amphibian 6 ft. R/C airplane which I had designed and which is produced in kit form by King R/C Distributors.

We talked about the problems—space envelope, weight and balance, power requirements, structural beef-ups. The *Wavemaster* is designed to fly at weights ranging from eight to nine lb. in normal use. With the TV

Author's *Wavemaster* amphibian R/C model is large and was used as a test bed for RPV experiments.



camera installed (including transmitter and power pack), it would have to fly at around 15 lb., according to original estimates. Actually, by the time all the modifications were added, the flying weight turned out to be closer to 20 lb!

At the time of Bob's call, I had just completed most of the flight test programme on the *Wavemaster* and had two prototypes available. As soon as we determined the camera would fit in the nose (ahead of the propeller as desired) and there was room for all the equipment, I shipped the two airplanes down to the Rye Canyon test facility. There they modified the landing gear to carry the added weight and also extended the wing to 8 ft. span. This concerned me, as I feared the percentage of tail area might be marginal. But flight tests eliminated the need for any concern—the airplane was very stable.

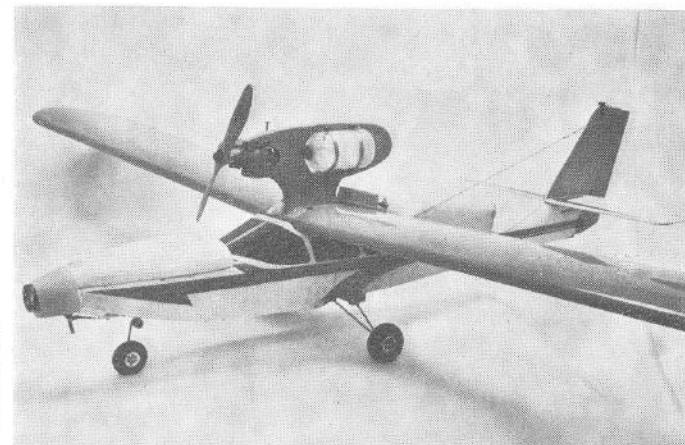
To perform the actual flight programme, two of the best known and best qualified R/C pilots in the world were selected. Larry Leonard and Bob Smith, familiar names to all R/C enthusiasts, took on the assignment. Although the plane was able to fly with a 61, even weighing nearly 20 lb., it was understandably a bit sluggish. So

an 80 was installed. This gave the plane good performance and a speed of about 60 m.p.h., or 1/10 the projected full-scale speed of 600 m.p.h. A model air field was constructed to 1/10 scale, and the feasibility tests were ready to start.

Larry took up his position, as 'pilot' inside the control van, looking at the TV screen on which the picture from the TV camera in the nose of the *Wavemaster* would be projected. Bob was outside, alongside the makeshift runway. Bob, having visual contact with the plane, held the master transmitter; Larry had the 'slave' or 'buddy box' transmitter in the van. Thus, Bob could position the *Wavemaster* until Larry, looking at the TV screen, achieved ground, horizon, and target acquisition. Then control shifted and Larry flew the model on the starting runs.

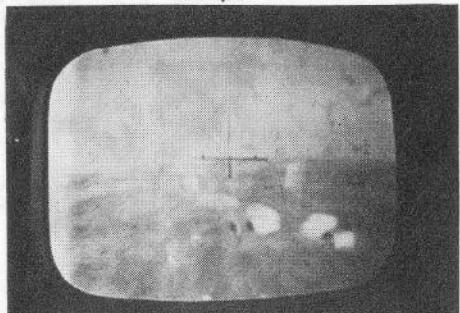
A second experiment was simulated air-to-air combat. A semi-scale P-51 R/C model, flown by a third modeller, was chased by the *Wavemaster* with Bob Smith at the controls until the P-51 appeared on the TV monitor screen. Then Larry took over, got on the P-51's tail and closed in to firing range.

The *Wavemaster* after modifications to take the RPV equipment. Note the TV camera mounted on nose. Power pod was stripped to take larger fuel tank.

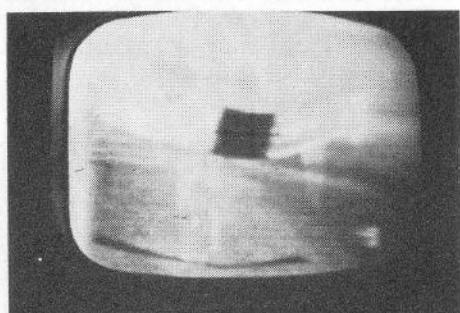




The Wavemaster takes off at an all-up-weight of some 20 lb. Model had a level speed of about 60 m.p.h.

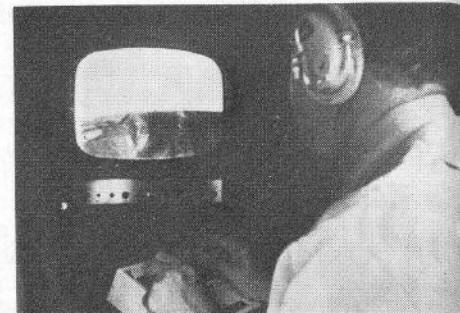


TV monitor picture of 15 ft. 'Strafing run' over sealed down 'airfield'.



Pilot accuracy test took form of head-on attack on crepe banner seen in middle of TV screen as model rushes towards it.

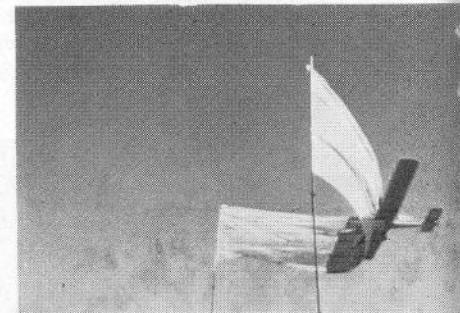
Finally, a simulated 'Kamikaze' mission was performed. A crepe paper barrier, approximately 15 ft. wide and three ft. high was strung between two poles. A bull's eye was painted dead centre. The Wavemaster was flown into acquisition position by Bob Smith. Then Larry, flying by reference to



After take-off control was switched to TV-guided pilot. TV monitor here has target in sight.



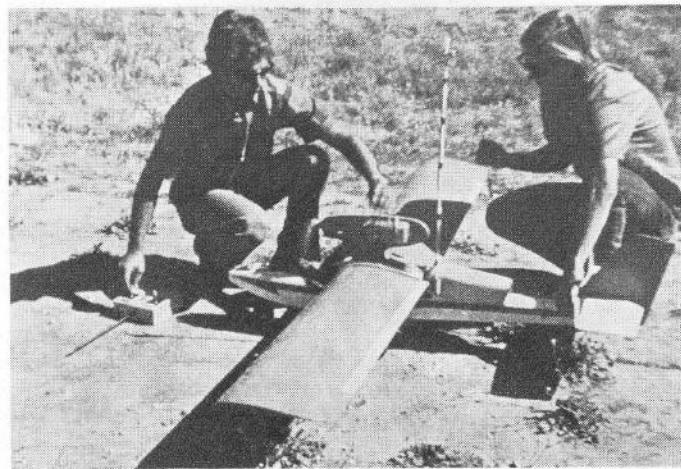
TV monitor here shows view of 'field' as Wavemaster attack craft climbs out after 'attack'. When horizons disappear, visual pilot takes over.



Moment of impact on target banner. Unfortunately the target won by wrapping itself around the model!

the TV monitor, directed the model towards the banner and scored a direct hit. The motion picture which recorded this is spectacular—to say the least—especially to an R/C audience.

Once again, the techniques of the sport of R/C flying were utilized to pursue an important objective of the



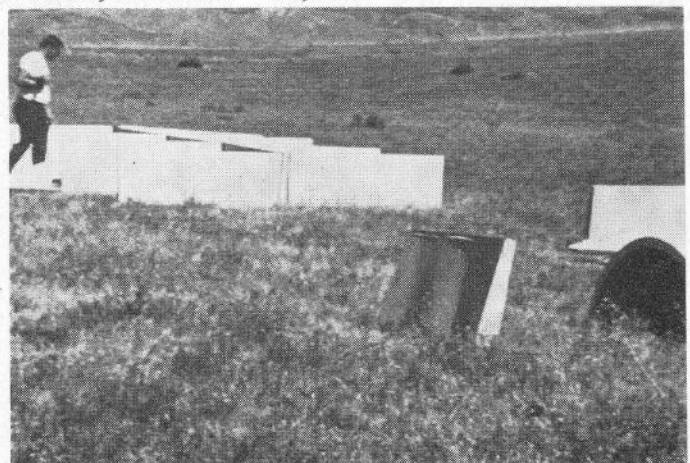
Active U.S. West Coast pylon race fliers Larry Leonard (left) and Bob Smith (right) acted as test pilots for the experiment, seen here preparing model for flight.

U.S. Department of Defence; at a great saving to the programme, and in turn to the American taxpayer. This low-cost feasibility demonstration showed both the capabilities and the limitations of the concept and pointed the way towards further sophistication required in order to increase the capabilities. All this at a cost less than one tenth of similar programmes.

An 'off-the-shelf' R/C model, modified to accommodate the airborne TV camera and controlled by an 'off-the-shelf' R/C transmitter and receiver, demonstrated that there is, in addition

to its recreational value, a technical and scientific utility capability of R/C whose potential is only beginning to achieve a measure of recognition. It is this aspect of R/C—which doesn't get headlines—that R/C enthusiasts must continue to foster, promote, and publicise. And progressive companies, like Lockheed, who are using some of our equipment in research and development, are helping to improve the image of R/C modelling at the same time they're saving money.

It's a good deal all round, and its fun, too.



The target—a simulated, 1/10th scale 'airfield', with hangars and revetment, is here prepared for the coming 'attack'.